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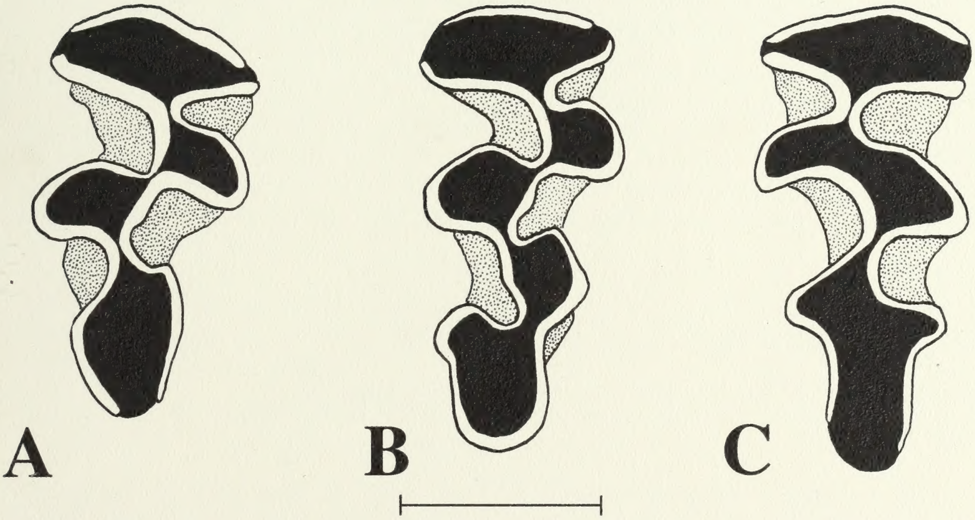

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SOUTHERN CALIFORNIA ACADEMY OF SCIENCES

2004 ANNUAL MEETING

May 14–15, 2004

CALIFORNIA STATE UNIVERSITY

LONG BEACH

Annual Meeting of the Southern California Academy of Sciences
California State University, Long Beach
May 14–15 2004 (Note change of date)

The Southern California Academy of Sciences will hold its 2004 annual meeting on the campus of the California State University, Long Beach. Presently planned symposium topics are listed below. Additional proposed symposium topics are invited. Please contact Raymond Wilson (*rwilson1 @csulb.edu*) or David Huckaby (*dhuckaby@csulb.edu*) at CSU, Long Beach to propose additional symposia.

Planned Symposia: Friday

Ecology and Taxonomy of Marine Invertebrates: Honoring the Legacy of Donald J. Reish: Held in conjunction with SCAMIT. contact John Dorsey at *jdorsey@lmu.edu*

Reef Ecology is a continuing symposium on the ecology of rocky substrates. If you wish to participate, contact Dan Pondella (*pondella@oxy.edu*) or Robert Grove (*grovers@sce.com*)

Environmental Simulation will be devoted to studies that model environmental processes. If you wish to participate please contact Drew Ackerman at SCCWRP (*drewa@sccwrp.org*)

Paleontology of Southern California will be devoted to recent discoveries on the prehistory of our area. Contact Mark Roeder (*mroeder1@earthlink.net*) if you wish to participate.

Planned Symposia: Saturday

Wetlands Ecology devoted to studies of the biological, chemical, and geological processes of Southern California's wetlands. Contact Tonny Wijte at CSU, Long Beach (*wijte@sculb.edu*) or Martha Sutula at SCCWRP (*marthas@sccwrp.org*)

Molecular Ecology of Southern California broadly devoted to ecological studies involving the use of molecular-genetic tools. Contact Raymond Wilson at CSU, Long Beach (*rwilson1@csulb.edu*)

Biological and Management Perspectives on Stress Responses in Fish: 'Catch & Release' and Other Human-derived Impacts; co-organized by Kevin Kelley (*kmkelley@csulb.edu*) and Chris Lowe (*clowe@csulb.edu*)

Molecular Biology of Cellular Processes. Contact Editte Gharakhanian at *eghara@csuld.edu* and/or Judith Brusslan at *bruss@csulb.edu*

Archaeology of Southern California; devoted to recent discoveries on the prehistory of our area. Contact Andrea Murray (*amurray@exchange.fullerton.edu*)

Contributed Papers: Sessions of Contributed Papers will occur both days.

See the SCAS webpage (http://scas.jsd.claremont.edu) for registration forms and information on meetings details.

Abstracts of presented papers and posters will be published in the August issue of the Bulletin.

Student Awards: Students who elect to participate are eligible for best paper or poster awards in the following categories. Biology: ecology and evolution, biology: genetics and physiology, physical science. A paper by any combination of student and professional co-authors will be considered eligible provided that it represents work done principally by student(s). In the case of an award to a co-authored paper, the monetary award and a one year student membership to the Academy will be made to the first author only.

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Arvicoline Rodents from Kokoweef Cave, Ivanpah Mountains, San Bernardino County, California

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Abstract.—A late Pleistocene/early Holocene faunal assemblage from Kokoweef Cave (San Bernardino County, California) includes a diverse assemblage of gastropods, reptiles, birds, and mammals. Chronological control for the site consists of a single radiocarbon date of 9830 ± 150 yr. BP taken from charcoal at approximately the vertical mid-point of the stratigraphic excavation. *Microtus* and *Lemmiscus* are extralimital and represent the only arvicoline rodents from the locality. We discovered several distinct morphotypes of the m1 of *Lemmiscus* from Kokoweef Cave, one of which is not known from any other populations, living or extinct. The recovery of an m1 morphotype with only four closed triangles is notable. This morphology is usually found in middle Pleistocene faunas, but is rare in younger localities. The loss of the 4-triangle morphotype of *Lemmiscus* represents one of the few documented small mammal morphotype 'extinctions' near the end of the Pleistocene in western North America.

Kokoweef Cave is situated at an elevation of approximately 1770 m on Kokoweef Peak, along an extension of the Ivanpah Mountains in San Bernardino County, California (Fig. 1; Goodwin and Reynolds 1989; Reynolds et al. 1991a). The site was the center of various mining activities for over 30 years until 1972 when paleontological crews from the San Bernardino County Museum began excavation of an extensive sequence of fossiliferous sediments. Discussion of the history of the cave excavations (mining and paleontological) was provided by Goodwin and Reynolds (1989) and Reynolds et al. (1991a). Published reports of the fauna include preliminary faunal lists (Harris 1985; Reynolds et al. 1991a), preliminary discussion of sigmodontine rodents (Austin 1992), and detailed analyses of the freshwater and terrestrial mollusks (Roth and Reynolds 1990), lizards (Norell 1986), sciurid rodents (Goodwin and Reynolds 1989), and woodrats (Force 1991). In this paper, we discuss the arvicoline rodents recovered from the cave.

Fossils were collected by previous researchers from a lower chamber of the cave; natural stratigraphy in the fossiliferous sands was not readily discernable and stratigraphic control was maintained by arbitrary 1-foot vertical levels, which may or may not have cross-cut dipping sediments (Goodwin and Reynolds 1989). The possibility that the sediments are temporally mixed by natural means (e.g., small slides from the upper portion of the cave, woodrat midden debris collapsing into the lower chambers) was discussed by Goodwin and Reynolds (1989), but they accepted that the sedimentary sequence preserved a "relatively accurate faunal history" (Goodwin and Reynolds 1989:23). Chronological control for the site is poorly established and there is no consistency in published reports of the ra-

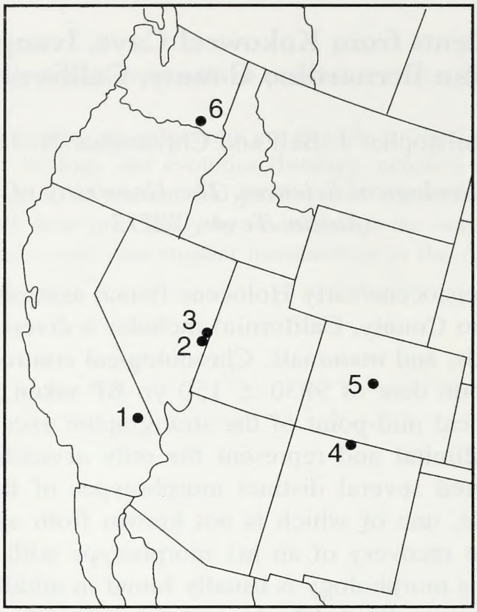

Fig. 1. Map showing location of Kokoweef Cave and other localities from which fossil m1s of *Lemmiscus* with only four closed triangles are known. 1. Kokoweef Cave and Antelope Cave; 2. Snake Creek Burial Cave; 3. Cathedral Cave; 4. SAM Cave; 5. Porcupine Cave; 6. Kennewick Roadcut.

diocarbon date(s) or the level(s) from which they were derived. Two radiocarbon dates were reported by Goodwin and Reynolds (1989). A date of 590 ± 120 yr. BP from the 31.5-foot level was considered to be derived from reworked charcoal, and was rejected. A more reliable date of 9830 ± 150 yr. BP was reported by Goodwin and Reynolds (1989) who indicated that it was taken on charcoal recovered from the 20.5 foot level (approximately 6 m above the base of the sequence) and that the date was provided by Beta Analytic (Beta-2155). The same information was provided by Roth and Reynolds (1990), but they attributed the date to a 1985 '*in litt.*' communication from Andrei Sarna-Wojcicki to R. E. Reynolds. The 9830 ± 150 yr. BP age also was reported by Reynolds et al. (1991a) but was said to be derived from the 21.5 foot level; in a separate paper in the same volume, Force (1991) gave the age and depth as 8950 ± 160 yr. BP from a depth of 7 m. An age of 9850 ± 160 yr. BP was given by Jefferson (1991). Thus, all authors report only one accepted radiocarbon date, and that accepted date is from sediments between 6 and 7 m above the base of the fossiliferous excavation (between 20.5 and 21.5 foot levels; see below).

At our request, Eric Scott of the San Bernardino County Museum recently located the original documentation for the radiocarbon dates. Beta Analytic sample 2155 yielded a corrected radiocarbon age of 9830 ± 150 yr. BP. A handwritten note in R. E. Reynolds' handwriting on a photocopy of the Beta report reads "at a depth of 21.5 ft. in sediments within the cave." The cover letter accompanying the report indicates that the sample required "extensive chemistry" for the pretreatment and "multiple burnings" in order to extract sufficient carbon for the analysis. No further information is available pertaining to the radiocarbon date or the charcoal sample from which it was made.

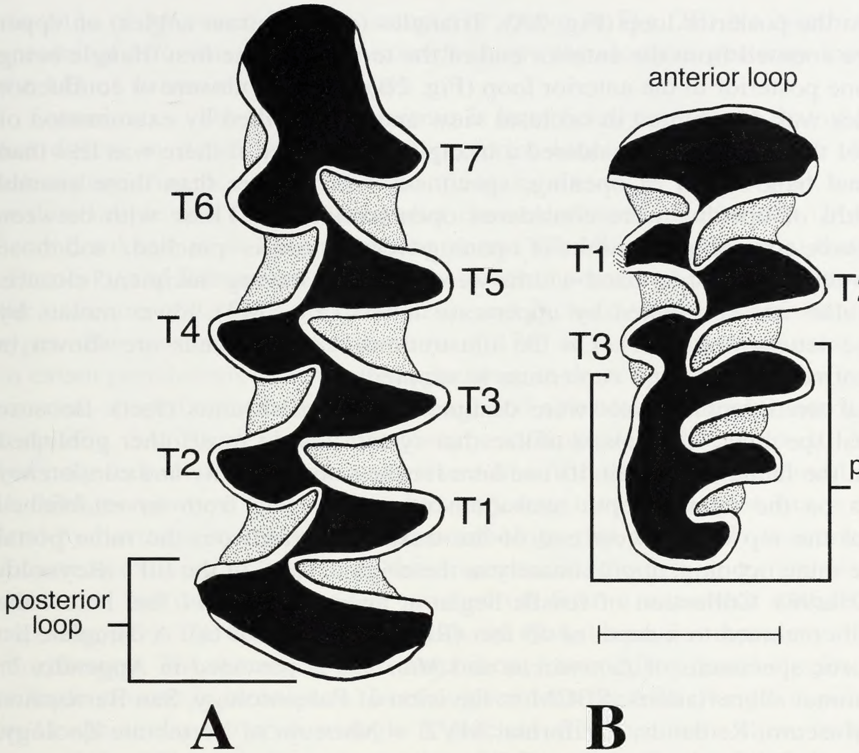

Fig. 2. *Microtus* specimens from Kokoweef Cave, showing dental terminology of arvicoline molars used in this paper. A, SBCM L1808-2652, left m1. B, SBCM L1808-1184, right M3. Scale bar = 1 mm.

Thus, the total time represented in the sediments is unknown, but the faunal components appear to be late Pleistocene and early Holocene in age. A Pleistocene component is represented by extinct llama, camel, and horse remains recovered from the cave (Reynolds et al. 1991a). Sediments stratigraphically above the radiocarbon date fall within the temporal span of the Holocene as it is generally recognized (Bell et al. in press[b]). We feel there is inadequate documentation to place any confidence in the presumed superpositional relationships of the sediments and their fossils; however, the low taxonomic diversity of arvicolines and their limited stratigraphic range renders stratigraphic analysis of change uninformative in any event. We thus treat the Kokoweef Cave arvicoline assemblage as a composite, or ‘bulk’ sample, of late Pleistocene to Holocene age.

Methods

All specimens are curated in the SBCM, under collection number L1808. Specimens were identified based on comparisons with dentitions of extant species of arvicolines, and descriptions from the literature. Dental terminology is shown on Figure 2. The number and configuration of triangles on the m1 and M3 of arvicolines are important for species determination and designation of intraspecific morphotype variation. Triangles (and reentrant angles) on lower molars are counted from the posterior end of the tooth, with the first triangle being the first one anterior to the posterior loop (Fig. 2A). Triangles (and reentrant angles) on upper molars are counted from the anterior end of the tooth, with the first triangle being the first one posterior to the anterior loop (Fig. 2B). Relative closure or confluence of triangles was determined in occlusal view and was verified by examination of the base of the molar. We considered a triangle to be closed if there was less than one enamel band width of opening; specimens with greater than three enamel band widths of opening were considered open (confluent). Those with between two and three enamel band widths of opening were scored as 'pinched,' and those with between one and two band widths were scored as having 'incipient' closure. Upper molars are designated by upper-case letters (e.g., M3), lower molars by lower-case letters (e.g., m1). On the illustrations, enamel bands are shown in white, dentine in black, and cementum is stippled.

Original stratigraphic levels were designated in English units (feet). Because all original specimen data labels utilize that system (as do most other published reports on the fauna), we retain its use here for the sake of clarity and consistency in reports on the fauna. Depth measurements were made from an established datum "at the top of the west end of the trestle that ran from the mine portal across the mine opening, approximately at the original level of the fill" (Reynolds et al. 1991a:98). Collection of fossils began at approximately 11 feet below the datum and continued to a depth of 45 feet (Reynolds et al. 1991a). A complete list of diagnostic specimens of *Lemmiscus* and *Microtus* is provided in Appendix 1.

Institutional abbreviations: SBCM = Division of Paleontology, San Bernardino County Museum, Redlands, California; MVZ = Museum of Vertebrate Zoology, University of California, Berkeley, California.

Results

Only two arvicoline taxa can be identified from the Kokoweef Cave deposit, *Microtus* and *Lemmiscus*. There are many extant North American species of *Microtus* (Hall 1981) and species identification of isolated teeth is not possible at this time (Bell and Mead 1998; Bell and Repenning 1999; Bell and Barnosky 2000). Only one species of *Lemmiscus* is currently recognized (*L. curtatus*), but several different dental morphologies are reported (see below). All arvicoline teeth from Kokoweef Cave are ever-growing, with cementum in the reentrant angles. Taxonomic identifications are based on phenetic similarity and not synapomorphy; the features we used to identify the specimens are discussed below.

Microtus.—Eight *Microtus* m1s were recovered from Kokoweef Cave (approximately 3% of the total arvicoline m1 sample of 228). All *Microtus* m1s include a posterior loop, five closed and alternating triangles, and a variable anterior cap (Fig. 2A). The second triangle is distinctly shorter than the first triangle, as is typical of *Microtus* (Barnosky and Rasmussen 1988); triangles 6 and 7 (the secondary wings of Repenning 1992) are well developed, but are not closed. No fewer than 12 extant North American *Microtus* species share this general m1 configuration (Bell and Barnosky 2000), and isolated m1s cannot be identified reliably to species.

The M3 of species of *Microtus* is highly variable, but those recovered from Kokoweef Cave (n = 9) are generally quite complex, with an anterior loop, two or three closed and alternating triangles, and a variably complex posterior portion. We did not quantify the morphological variation in the occlusal morphology of the M3s of *Microtus,* but an example is shown in Fig. 2B. No North American species of *Microtus* (extant or extinct) shows the elongate posterior loop seen in the M3 of *Lemmiscus* (see below).

Lemmiscus.—The m1 of *Lemmiscus* is superficially similar to that of *Microtus,* but differs in detail. It includes a posterior loop, and usually five closed and alternating triangles (sometimes as many as six, or as few as four are closed), with a simple and usually somewhat crescent-shaped anterior cap (Fig. 3). The second triangle is as long or longer (across the labial-lingual axis) than the first (Barnosky and Rasmussen 1988). Ninety-seven percent of the arvicoline m1s from the cave are of *Lemmiscus* (n = 220), and include several noteworthy morphotypes. The most common of these (n = 176) is the morphotype most prevalent in extant populations of *Lemmiscus curtatus*; in these specimens, there is a simple, crescent-shaped anterior cap, five closed and alternating triangles, and a posterior loop (Fig. 3A, B). A second morphotype in Kokoweef Cave (n = 10) is similar, but only four closed triangles are present (the fifth triangle is not closed; Fig. 3C). A third morphotype (n = 8) also has only four closed triangles, but is characterized by having a modified anterior morphology that previously was unknown for *Lemmiscus* (living or fossil). In these specimens, the fifth and sixth triangles are confluent, but they are closed or pinched off from a somewhat rounded anterior cap (Fig. 3D). The five specimens with six closed triangles represent a fourth m1 morphotype. The remaining specimens show intermediate morphologies, in which triangle closure is incomplete. In two specimens the fifth triangle is pinched, and in 11 specimens the sixth triangle is pinched. Six specimens show incipient closure of the fifth triangle, and two show incipient closure of the sixth triangle.

A total of 126 *Lemmiscus* M3s were recovered from Kokoweef Cave. Most of these (n = 94) share a basic morphology (Fig. 4A, labeled as 'Type 1' in Appendix 1) consisting of an anterior loop, at least two triangles (usually closed), an elongate posterior loop, and anteroposteriorly expanded (somewhat 'squared') first lingual and second labial reentrants (Barnosky and Rasmussen 1988; Repenning 1992). Other morphological variants within the M3 sample of *Lemmiscus* include specimens (n = 18) in which a third triangle is moderately to well developed, but not closed (Fig. 4B). In three specimens, the anterior loop is followed by two triangles that are confluent with one another (Fig. 4C) and in one of these the first triangle is also confluent with the anterior loop. In ten specimens the second triangle is confluent with the posterior loop (and in two of those ten, the first triangle is also confluent with the anterior loop, but the two triangles are closed from one another). In one specimen two triangles are present and closed from one another, but the first is confluent with the anterior loop. The three specimens in which the first triangle is confluent with the anterior loop show the shallow first buccal reentrant angle discussed by Rensberger et al. (1984) and Barnosky and Rasmussen (1988).

Discussion and Conclusion

Microtus is widely distributed throughout California today and populations occur to the north, northwest, west, and southwest of Kokoweef Cave (Hall 1981), but neither *Lemmiscus curtatus* nor *Microtus* are found in the vicinity of Kokoweef Cave today (Ingles 1947; Johnson et al. 1948; Hall 1981). Marginal records reported by Hall (1981) indicate that the nearest extant populations of *Lemmiscus*

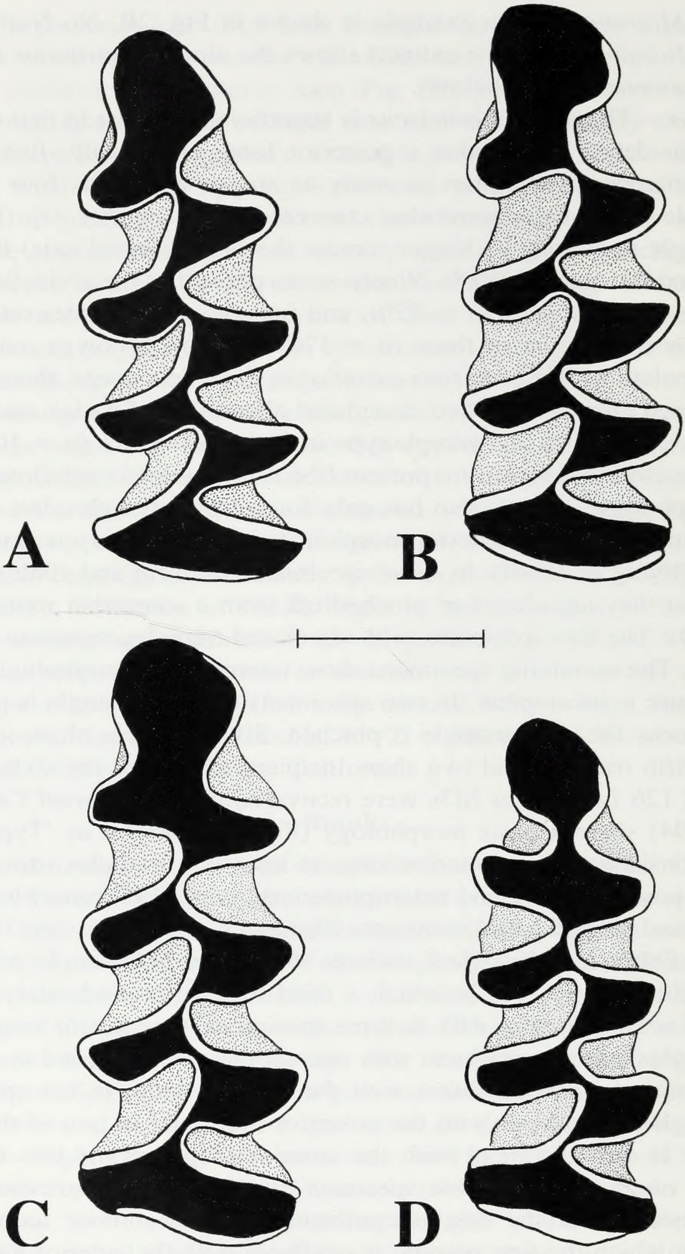

Fig. 3. *Lemmiscus* m1 specimens from Kokoweef Cave. A, SBCM L1808-2620, the 'typical' morphotype with five closed triangles; B, SBCM L1808-2556, another 'typical' morphotype; C, SBCM L1808-2557, a morphotype with only four closed triangles; D, SBCM L1808-2548, a new morphotype of *Lemmiscus* with four closed triangles, but fifth and sixth confluent and nearly closed off from a simple, rounded cap. Scale bar = 1 mm.

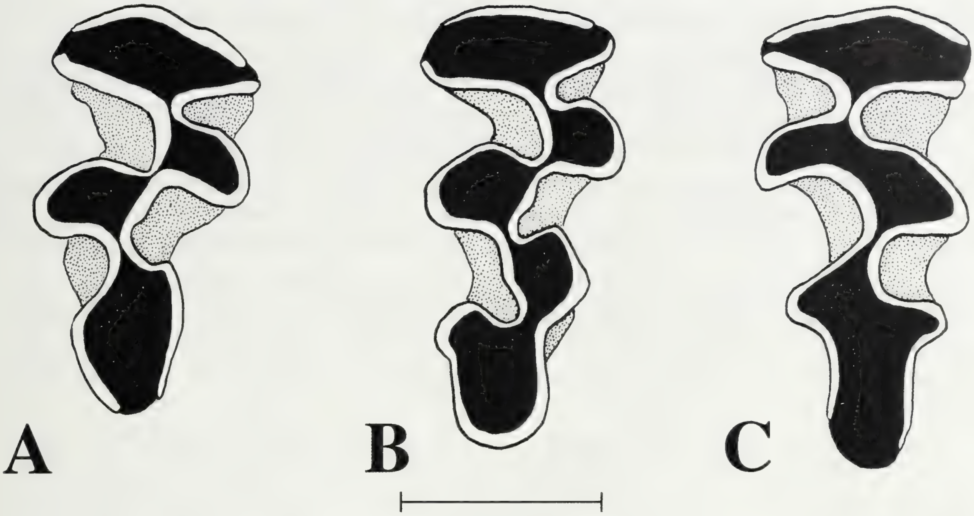

Fig. 4. *Lemmiscus* M3 specimens from Kokoweef Cave. A, SBCM L1808-2820, the typical morphotype with only two closed triangles; B, SBCM L1808-2828, a more complex morphotype with a well-developed third triangle; C, SBCM L1808-2801, first and second triangles confluent. Scale bar = 1 mm.

are in the Inyo Mountains, approximately 265 km to the northwest. The only other fossil record of *Lemmiscus* in California was reported from Antelope Cave, approximately 4.8 km west-northwest of Kokoweef Cave (Jefferson 1991; Reynolds et al. 1991b). We examined this material and found 11 m1s. Seven show a typical morphology with five closed triangles, two have six closed triangles, one has a pinched sixth triangle, and one specimen has only four closed triangles. The Antelope Cave fossils were recovered from unstratified back-dirt derived from within the cave (Reynolds et al. 1991b). A single radiocarbon date of 11,080 ± 160 yr. BP (taken from an ulnar shaft of a condor) was reported by Emslie (1990).

There are five other fossil localities that produced 4-triangle morphotypes of *Lemmiscus.* Three of these are cave localities of middle Pleistocene (Irvingtonian) age and include the earliest known records of *Lemmiscus.* The oldest known record is from the lower levels of the Pit excavation in Porcupine Cave, dating to between 0.85 and 1 Ma (Bell and Barnosky 2000; Barnosky and Bell in press). Approximately contemporaneous material was recovered from the oldest deposits in SAM Cave, New Mexico (Rogers et al. 2000). The SAM Cave deposits have both 4- and 5-triangle morphotypes present, but there are inconsistencies between the stratigraphic distributions plotted on table 2 of Rogers et al. (2000:96) and the faunal list and catalogue in their appendix (Rogers et al. 2000:115). Both morphotypes are also present in the Cathedral Cave fauna in Nevada (Bell 1995; Bell and Barnosky 2000) and at least four other excavations in Porcupine Cave in Colorado (the Gypsum Room, Kate's Cupola/Mark's Sink locality, Carnegie Museum Velvet Room excavation, and Denver Museum of Natural History Velvet Room excavation; Bell et al. in press[a]). The Ferret Room fauna in Porcupine Cave contains a single specimen of a 4-triangle morphotype of *Lemmiscus,* but it is one of only three arvicoline specimens recovered (Bell et al. in press[a]).

The Kennewick Roadcut locality in Washington was the first locality from which 4-triangle m1 morphotypes of *Lemmiscus* were reported (Rensberger et al. 1984). 4- and 5-triangle m1 morphotypes were recovered throughout the section, but their relative abundance changes, with 5-triangle forms gaining in importance upsection (Rensberger et al. 1984; Rensberger and Barnosky 1993). In the upper units of the Kennewick Roadcut, 6-triangle morphotypes occur in low abundance (Rensberger and Barnosky 1993), and they are found in low abundance in several modern populations, and as a regular feature in at least some populations from northern Nevada (Barnosky and Bell, from unpublished data based on examination of the collections in the MVZ). The age of the Kennewick sequence is not well established, especially for the lower portions of the section, which may be entirely within the Rancholabrean mammal age (Rensberger and Barnosky 1993) or may include an Irvingtonian mammal age faunal component (Bell et al. in press[b]).

The youngest known occurrence of a 4-triangle morphotype of *Lemmiscus* is from Unit III in Snake Creek Burial Cave in Nevada (Bell and Mead 1998), with a radiocarbon date at the top of the unit of 9460 ± 160 yr. B.P. (Mead and Mead 1989). The numerous other Pleistocene and Holocene faunas that include *Lemmiscus* are not reported to contain any 4-triangle morphotypes (Kurtén and Anderson 1980; Harris 1993; FAUNMAP Working Group 1994; Bell and Glennon in press; Mead et al. in press), and this morphology is unknown from extant populations of *Lemmiscus* (Bell and Barnosky 2000).

Available evidence thus suggests that throughout their evolutionary history, *Lemmiscus* populations were characterized by evolution of increasing morphological complexity of the m1, initially by closing off the fifth triangle, and eventually by development and closure of a sixth triangle. This general pattern was observed in stratified deposits in Washington (Kennewick) and Colorado (Porcupine Cave), and is supported by the morphotypes found in other Pleistocene localities. The Kokoweef Cave assemblage records one of the youngest occurrences of the 4-triangle morphotype, and is one of only three localities containing this morphotype that fall within the range of radiocarbon dating techniques (Antelope Cave and Snake Creek Burial Cave are the others; see above). Loss of this morphology in *Lemmiscus* populations represents one of the few readily discernable small mammal morphotype 'extinctions' near the end of the Pleistocene in North America.

Acknowledgments

Robert E. Reynolds originally suggested this study and was responsible for the excavations that resulted in collection of the specimens reported here. We appreciate the patience and understanding of Kathleen Springer and Betsy Slemmer at SBCM during what turned out to be a long-term loan of the specimens. Eric Scott was especially helpful to us in facilitating curation of specimens and for his extensive help in tracking down original documentation pertaining to the collection and the radiocarbon date. Jeff Horowitz prepared Figure 1, and Kate Reynolds prepared figures 2, 3, and 4. We benefited from years of discussion about *Lemmiscus* with Tony Barnosky and Charles Repenning, and their contributions to our thinking are gratefully acknowledged. Comments on an earlier draft of this paper were provided by Amy Balanoff, Gabe Bever, Eric Ekdale, Christian George, Ted Macrini, Jim Mead, Holly Nance, Dennis R. Ruez, Jr., Geraldine Swartz, Patrick Wheatley, and Richard Zakrzewski.

Literature Cited

Austin, K. E. 1992. Methods of identifying fossil small cricetid rodents: Applications to the late Quaternary Kokoweef Cave fauna. P. 21 *in* Abstracts of Proceedings from the 6th Annual Mojave Desert Quaternary Research Symposium, May 15–16, 1992. (J. Reynolds, compiler), San Bernardino County Mus. Assoc. Quarterly, 39(2).

Barnosky, A. D., and C. J. Bell. In press. Age and correlation of key fossil sites in Porcupine Cave. Chapter in Biodiversity Response to Environmental Change in the Early and Middle Pleistocene: The Porcupine Cave Fauna from Colorado (A. D. Barnosky, ed.), Univ. California Press, Berkeley.

———, and D. L. Rasmussen. 1988. Middle Pleistocene arvicoline rodents and environmental change at 2900-meters elevation, Porcupine Cave, South Park, Colorado. Ann. Carnegie Mus., 57:267–292.

Bell, C. J. 1995. A middle Pleistocene (Irvingtonian) microtine rodent fauna from White Pine County, Nevada, and its implications for microtine rodent biochronology. J. Vert. Paleontol., 15 (Supplement to 3):18A.

———, and A. D. Barnosky. 2000. The microtine rodents from the Pit locality in Porcupine Cave, Park County, Colorado. Ann. Carnegie Mus., 69:93–134.

———, and J. Glennon. In press. Arvicoline rodents from Screaming Neotoma Cave, southern Colorado Plateau, Apache County, Arizona, with comments on the Pleistocene biogeography of *Lemmiscus curtatus*. *In* Ice Age Cave Faunas of North America. (B. S. Schubert, J. I. Mead, and R. W. Graham, eds.), Indiana Univ. Press in cooperation with the Denver Museum of Science.

———, and J. I. Mead. 1998. Late Pleistocene microtine rodents from Snake Creek Burial Cave, White Pine County, Nevada. Great Basin Nat., 58:82–86.

———, and C. A. Repenning. 1999. Observations on dental variation in *Microtus* from the Cudahy Ash Pit fauna, Meade County, Kansas and implications for Irvingtonian microtine rodent biochronology. J. Vert. Paleontol., 19:757–766.

———, C. A. Repenning, and A. D. Barnosky. In press(a). Arvicoline rodents from Porcupine Cave, Park Co., Colorado: Identification, spatial distribution, and taxonomic assemblages. Chapter in Biodiversity Response to Environmental Change in the Early and Middle Pleistocene: The Porcupine Cave Fauna from Colorado (A. D. Barnosky, ed.), Univ. California Press, Berkeley.

———, E. L. Lundelius, Jr., A. D. Barnosky, R. W. Graham, E. H. Lindsay, D. R. Ruez, Jr., H. A. Semken, Jr., S. D. Webb, and R. J Zakrzewski. In press(b). The Blancan, Irvingtonian, and Rancholabrean mammal ages. Chapter in Late Cretaceous and Cenozoic Mammals of North America: Geochronology and Biostratigraphy (M. O. Woodburne, ed.). Columbia University Press.

Emslie, S. D. 1990. Additional ^{14}C dates on fossil California condor. Natl. Geogr. Res., 6:134–135.

FAUNMAP Working Group. 1994. FAUNMAP: A database documenting late Quaternary distributions of mammal species in the United States. Illinois State Mus. Scientific Papers, 25:1–690.

Force, C. 1991. Late Pleistocene–early Holocene woodrat (*Neotoma* sp.) dental remains from Kokoweef Cave, San Bernardino County, California. Pp. 104–106 *in* Crossing the Borders: Quaternary Studies in Eastern California and Southwestern Nevada. (R. E. Reynolds, compiler), San Bernardino County Mus. Assoc. Special Pub., MDQRC 1991. San Bernardino County Mus. Assoc., Redlands, California.

Goodwin, H. T., and R. E. Reynolds. 1989. Late Quaternary Sciuridae from Kokoweef Cave, San Bernardino County, California. Bull. Southern California Acad. Sci., 88:21–32.

Hall, E. R. 1981. The Mammals of North America. John Wiley & Sons, New York, New York, 1181 pp.

Harris, A. H. 1985. Late Pleistocene Vertebrate Paleoecology of the West. Univ. Texas Press, 293 pp.

———. 1993. Quaternary vertebrates of New Mexico. Pp. 179–197 *in* Vertebrate Paleontology in New Mexico. (S. G. Lucas, and J. Zidek, eds.), New Mexico Mus. Nat. Hist. and Sci. Bull., 2.

Ingles, L. G. 1947. Mammals of California. Stanford Univ. Press, 258 pp.

Jefferson, G. T. 1991. A catalogue of late Quaternary vertebrates from California: Part two, mammals. Nat. Hist. Mus. Los Angeles County Technical Reports, 7:1–129.

Johnson, D. H., M. D. Bryant, and A. H. Miller. 1948. Vertebrate animals of the Providence Mountains area of California. Univ. California Pub. Zoöl., 48:221–376.

Kurtén, B., and E. Anderson. 1980. Pleistocene Mammals of North America. Columbia Univ. Press, 442 pp.

Mead, E. M., and J. I. Mead. 1989. Snake Creek Burial Cave and a review of the Quaternary mustelids of the Great Basin. Great Basin Nat., 49:143–154.

Mead, J. I., L. L. Coats, and B. W. Schubert. In press. Late Pleistocene faunas from caves in the eastern Grand Canyon, Arizona. *In* Ice Age Cave Faunas of North America. (B. S. Schubert, J. I. Mead, and R. W. Graham, eds.), Indiana Univ. Press in cooperation with the Denver Museum of Science.

Norell, M. A. 1986. Late Pleistocene lizards from Kokoweef Cave, San Bernardino County, California. Copeia, 1986:244–246.

Rensberger, J. M., and A. D. Barnosky. 1993. Short-term fluctuations in small mammals of the late Pleistocene from eastern Washington. Pp. 299–342 *in* Morphological Change in Quaternary Mammals of North America. (R. A. Martin, and A. D. Barnosky, eds.), Cambridge Univ. Press, Cambridge.

———, A. D. Barnosky, and P. Spencer. 1984. Geology and paleontology of a Pleistocene-to-Holocene loess succession, Benton County, Washington. Eastern Washington Univ. Reports in Archaeology and History, 100-39:1–105.

Repenning, C. A. 1992. *Allophaiomys* and the age of the Olyor Suite, Krestovka Sections, Yakutia. U.S. Geol. Surv. Bull., 2037:1–98.

Reynolds, R. E., R. L. Reynolds, C. J. Bell, N. J. Czaplewski, H. T. Goodwin, J. I. Mead, and B. Roth. 1991a. The Kokoweef Cave faunal assemblage. Pp. 97–103 *in* Crossing the Borders: Quaternary Studies in Eastern California and Southwestern Nevada. (R. E. Reynolds, compiler), San Bernardino County Mus. Assoc. Special Pub., MDQRC 1991. San Bernardino County Mus. Assoc., Redlands, California.

———, R. L. Reynolds, C. J. Bell, and B. Pitzer. 1991b. Vertebrate remains from Antelope Cave, Mescal Range, San Bernardino County, California. Pp. 107–109 *in* Crossing the Borders: Quaternary Studies in Eastern California and Southwestern Nevada. (R. E. Reynolds, compiler), San Bernardino County Mus. Assoc. Special Pub., MDQRC 1991. San Bernardino County Mus. Assoc., Redlands, California.

Rogers, K. L., C. A. Repenning, F. G. Luiszer, and R. D. Benson. 2000. Geologic history, stratigraphy, and paleontology of SAM Cave, north-central New Mexico. New Mexico Geol., 22:89–100, 113–117.

Roth, B., and R. E. Reynolds. 1990. Late Quaternary nonmarine Mollusca from Kokoweef Cave, Ivanpah Mountains, California. Bull. Southern California Acad. Sci., 89:1–9.

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Appendix 1

Diagnostic specimens of *Lemmiscus* and *Microtus* from Kokoweef Cave. Specimens are arranged by taxon, element, morphotype, and stratigraphic depth. I = incipient closure (see text for explanation); P = pinched closure (see text for explanation); T# = triangle number (see Fig. 2 for dental terminology); Type 1 = 'typical' morphotype of *Lemmiscus* M3, with an anterior loop, two closed triangles, and an elongated posterior loop; #T = number of closed triangles present. Stratigraphic designations are in feet below datum (see Reynolds et al. 1991a). Specimen numbers (provided parenthetically) are numbered within SBCM collection number L1808.

***Lemmiscus* m1, 4T morphotype (n = 10)**: Level 22/23 NW (2502, 2526); Level 23/24 (2557); Level 23/24 NW (2541); Level 25/26 NW (2599); Level 27/28 SW (2612); Level 28/29 SW (2615, 2621); Level 28/29 NW (2629); Level 29/30 SW (2636). ***Lemmiscus* m1, 4T morphotype with T5-T6 confluent and pinched from cap (n = 8)**: Level 22/23 NW (2529); Level 23/24 (2709); Level 23/24 NW (1212, 2548); Level 28/29 SW (2618, 2625); Level 29/30 (2650); Level 38/39 SW (2668). ***Lemmiscus* m1, P5 morphotype (n = 2)**: Level 22/23 W (2498); Level 23/24 (2688). ***Lemmiscus* m1, I5 morphotype (n = 6)**: Level 22/23 NW (2511); Level 23/24 (2684, 2694); Level 23/24 NW (2550); Level 27/28 SW (2614); Level 28/29 SW (2617). ***Lemmiscus* m1, 5T morphotype (n = 165)**: Level 21 (2491–2493); Level 21 NW (2494–2496); Level 22/23 NW (2503–2510, 2512–2521, 2523–2525, 2527–2528, 2531–2534); Level 23–24 (2556, 2673–2680, 2682–2683, 2686–2687, 2689–2693, 2695–2701, 2703–2706, 2708, 2710); Level 23/24 SW (1216, 2537–2539); Level 23/24 NW (1214–1215, 2542–2547, 2549, 2551–2555); Level 24/25 SW (2560, 2562, 2565–2566); Level 24/25 NW (2572–2581, 2583–2589); Level 25/26 SW (2591–2592); Level 25/26 NW (2594–2598, 2600–2604); Level 26/27 NW (2605, 2607–2610, 2671); Level 27/28 SW (2613); Level 28/29 (2630); Level 28/29 SW (1227–1228, 2616, 2619–2620, 2622–2624, 2626–2628); Level 29/30 (2651); Level 29/30 SW (2633–2635, 2637–2648); Level 31.5/32 (2653–2655); Level 31.5/32 W (2656); Level 32/33 W (2657–2658); Level 34/35 SW (2659–2660); Level 36/37 SW (2663–2665); Level 38/39 SW (2666–2667); Level 39/40 SW (2669–2670). ***Lemmiscus*, dentary fragment with 5T morphotype m1 (some specimens with additional teeth) (n = 11)**: Level 22/23 (2535); Level 22/23 W (2497); Level 22/23 NW (2501); Level 23/24 NW (2540); Level 24/25 SW (2559); Level 24/25 NW (2568–2571); Level 29/30 SW (2632); Level 36/37 SW (2662). ***Lemmiscus* m1, P6 morphotype (n = 11)**: Level 22/23 NW (2522, 2530); Level 23/24 SW (2536); Level 23/24 (2681, 2707, 2711); Level 24/25 SW (2561, 2564); Level 24/25 NW (2582); Level 29/30 SW (2649); Level 35/36 SW (2661). ***Lemmiscus* m1, I6 morphotype (n = 2)**: Level 23/24 (2685); Level 25/26 SW (2590). ***Lemmiscus* m1, 6T morphotype (n = 5)**: Level 22/23 W (2499); Level 23/24 (2702); Level 24/25 SW (2563); Level 26/27 NW (2606); Level 27/28 SW (2611). ***Lemmiscus* M3, Type 1 (n = 94)**: Level 21 NW (2712–2713, 2715–2716); Level 22/23 NW (2717–2722, 2724–2726, 2728–2732); Level 23/24 (2735, 2737–2741, 2744, 2746–2752); Level 23/24 SW (1206, 2766–2769); Level 23/24 NW (1185 [partial skull with left and right M3], 1205, 2753, 2755, 2757–2758, 2759 [partial skull with right M3], 2760, 2763, 2765); Level 24/25 SW (2774–2778); Level 24/25 NW (2770, 2773); Level 25/26 SW (2792–2795); Level 25–26 NW (2781–2786, 2789–2791); Level 26/27 NW (2796–2798); Level 28–29 (2800); Level 28–29 SW (2805, 2808); Level 28–29 NW (2802–2804); Level 29/30 (2809–2812); Level 29/30 SW (2814–2822); Level 30/31 W (2823–2824); Level 31.5/32 W (2825); Level 39/40 SW (2830). ***Lemmiscus* M3, T3 moderately or well developed (n = 18)**: Level 21 NW (2714); Level 22/23 NW (2723, 2727); Level 23/24 (2736, 2742–2743, 2745); Level 23/34 SW (1204); Level 23/24 NW (2754, 2756); Level 24/25 NW (2771); Level 24/25 SW (2779); Level 25/26 (2780); Level 25/26 NW (2787); Level 28/29 SW (2806); Level 37/38 SW (2826); Level 38/39 SW (2828); Level 39/40 SW (2831). ***Lemmiscus* M3, 2T, T2 confluent with posterior loop (n = 10)**: Level 22/23 W (2734); Level 23/24 SW (1203); Level 23/24 NW (2761, 2764); Level 24/25 NW (2772, T1 confluent with anterior loop); Level 25/26 NW (2788); Level 26/27 NW (2799); Level 29/30 W (2813); Level 38/39 SW (2827 [T1 confluent with anterior loop], 2829). ***Lemmiscus* M3, 2T, T1 and T2 confluent (n = 3)**: Level 24/25 NW (2772, T1 also confluent with anterior loop); Level 28/29 SW (2807); Level 28/29 NW (2801). ***Lemmiscus* M3, 2T, T1 confluent with anterior loop (n = 1)**: Level 23/24 NW (2762). ***Microtus* m1, 5T morphotype (n = 8)**: Level 22/23 NW (2500); Level 23/24 (2672); Level 23/24 SW (1184); Level 24/25 SW (2558); Level 24/25 NW (2567); Level 25/26 NW (2593); Level 29 (2631); Level 31.5/32 (2652). ***Microtus* M3 (n = 9)**: Level 22/23 NW (2832); Level 23/24 (2833); Level 23/24 SW (1184); Level 23/24 NW (2834); Level 24/25 SW (2835); Level 25/26 NW (2836–2838); Level 30/31 W (2839).

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The Role of Biotic and Abiotic Variables in Determining Demographic Processes in an Eelgrass Meadow

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Abstract.—Using principal component analysis among biotic and abiotic variables we found coherent subsets of variables that explain biological processes such as growth, mortality and recruitment in a seagrass (*Zostera marina*) meadow. The analysis of eigenvalues extracted three significant factors, which together accounted for 63% of the variability. The first factor was mostly determined by demographic variables (shoot density, growth, and above- and below-ground biomass). The second principal component was represented by abiotic variables such as temperature and solar radiation. The third factor was mainly defined by nutrient concentration (phosphates and nitrates). We found high negative correlation coefficients between many biotic variables and temperature, which is contrary to some literature reports. This negative correlation coefficient might be due to a compounded lag effect on the meadow of the strong "El Niño" event which occurred during 1998 followed by an equally strong "La Niña event" that took take place in 1999. Variables with correlation less than ± 0.30 were dropped from the analysis. The plots of the abiotic principal components against biotic variables are presented.

For many conditions, demography allows the calculation of the strength of selection on life-history traits (Stearns 1992). This means that the demography of a population may change depending on conditions such as antropogenic perturbations and environmental conditions. Seagrass meadows for example, are very vulnerable to physical perturbations caused by climatic, tidal conditions and human activity (den Hartog & Polderman 1975; Orth & Moore 1986; Shepherd et al. 1989). Such perturbations can produce changes in the expansion and mortality of shoots and therefore in the demography of the meadow. In fact, there is a controversy among authors about the relationship between productivity and temperature for *Zostera marina.* Some authors argue that temperature controls vegetative growth and productivity (Setchell 1929; Jacobs 1979; Penhale 1977) while others claim that temperature does not control productivity (Phillips 1974; Sand-Jensen 1975; Riggs & Fralick 1975). Nevertheless, Short and Neckles (1999), point out that increasing water temperature will directly affect seagrasses by changing species abundance and distribution, and might alter plant productivity. Furthermore, it has been shown for *Zostera marina* that nutrient concentration in sediments is related to some biotic variables such as shoot height, leaf area and leaf growth biomass (Short 1987). Nevertheless, on a quantitative basis the relationships have not been characterized. Moreover, positive correlation coefficients have been reported between temperature and some biotic variables such as density, above and below ground biomass, new and present leaves and leaf growth (Aioi

1980; Ibarra-Obando and Huerta-Tamayo 1987; Solana et al. 1997; Ibarra-Obando et al. 1997). This is in contradiction with our results, in which we found that many biotic variables are highly negatively correlated with minimum temperature (Table I). Such negative correlation coefficients might be due to a compounded lag effect on the meadow of a strong El Niño event which occurred during 1998, followed by an equally strong La Niña event that took take place in 1999.

In this paper we use Principal Component Analysis (PCA) among biotic and abiotic variables to detect a coherent subset of factors (Tabachnick and Fidell 2001) that can elucidate some demographic processes. We use PCA to determine how these coherent subsets affect biological processes of growth, recruitment, mortality etc. It is expected that these subsets of factors can explain the underlying processes that resulted in the high correlation among variables. We describe these processes in accordance with the components that explain the largest amount of variation in the variables analyzed.

Since the success of a population relies on recruitment and mortality, which determine demography, it is important to know the abiotic variables that affect these processes in order to understand and perhaps control those effects. Therefore, the study of the relationships between biotic and abiotic variables can help to describe and understand demographic processes so that future models can be proposed. For example, if we know that temperature determines the rate of seagrass growth, such that high temperature slows growth and low temperature increases it, then it is possible to propose a model that replicates this process.

Methods

The study was carried out in the Punta Banda Estuary located on the Coast of northern Baja California, México (31°40′ N–31°48′ N, 116°37′–116°40′W). For a complete description of the sample site see Solana et al. (2000). Twenty rhizomes about one meter long were marked biweekly from January to December 2000. Since we always sample at low tide, it was possible to prevent breakage, to handle very carefully every rhizome, marking every shoot in it using Zieman's marking technique (Zieman 1968). The rhizomes were selected at random from an area 3 m wide and 40 m long. All shoots present along the rhizome were also counted and the number of leaves present on each shoot was recorded at the site. After fifteen days, marked rhizomes were removed from the site and a new set of shoots was marked. Samples were placed in individually labeled plastic bags and refrigerated at 5°C until processed in the laboratory. Once in the laboratory all the material was cleaned with distilled water. The following demographic measurements were taken: number of nodes in each rhizome, length and dry weight of each internode, number of leaves present in each shoot; length, width, dry weight and growth of each leaf, number of new leaves in each shoot, number of lateral shoots in each rhizome, and number of new leaves inside the sheath. The age of each rhizome and each shoot was determined by adding the number of scars left by abscission of leaves through time and the number of leaves present in the shoot (principal shoot for the age of the rhizome). Since all shoots were marked along the rhizomes, the number of new shoots was determined as the number of shoots with no mark in the leaves.

Density and biomass were measured monthly using six 400 cm^2 quadrate selected at random from an area adjacent to the zone where rhizomes were marked.

Table 1. Correlation between biotic and abiotic variables.

Variable	Phosphate Concentration (PH)	Nitrate Concentration (N)	Maximum Temperature (MT)	Minimum Temperature MNT	Mean Temperature (AVT)	Aire Radiation (AR)	Under water Radiation (UR)	Salinity (S)
Shoot Density (SD)	0.20	0.10	**−0.60**	**−0.67**	**−0.44**	0.08	−0.20	**−0.35**
Above Ground Biomass (AB)	−0.16	**0.35**	−0.07	**−0.46**	0.00	0.23	**−0.56**	**−0.32**
Below Ground Biomass (BB)	−0.05	0.11	−0.10	**−0.46**	0.00	0.06	0.06	−0.00
Total Biomass (TB)	−0.08	**−0.38**	0.14	**−0.37**	0.22	**−0.31**	**−0.65**	−0.21
Growth (G)	−0.26	0.03	0.19	**−0.55**	−0.11	0.10	0.28	−0.06
Node Number (NN)	0.28	0.02	0.03	**−0.36**	0.02	0.16	−0.02	0.10
Present Leaves (PL)	**−0.35**	**0.31**	0.11	0.08	0.20	0.16	**0.54**	−0.09
Age (A)	0.18	0.08	0.08	**−0.42**	0.07	0.16	0.10	0.09
New Leaves (NL)	0.03	0.03	−0.03	0.01	−0.09	0.05	0.06	0.15
Leaves Inside Sheath (LIS)	**0.32**	−0.04	**−0.33**	−0.01	−0.20	−0.20	**−0.46**	**−0.31**
Lateral Shoots (LS)	**0.32**	−0.03	**−0.46**	0.03	**−0.44**	0.03	**−0.43**	−0.01
Node Length (NLG)	**0.31**	0.15	0.08	0.04	0.11	−0.14	−0.01	0.03
New Shoots (NS)	**0.36**	0.19	−0.21	−0.08	−0.17	−0.02	**−0.37**	−0.22

From the six quadrants sampled we measured number of shoots per unit area and above and below ground biomass. Abiotic variables such as maximum, minimum and mean daily temperature, photosynthetically active radiation in air and under water were recorded with a Li-cor1400 data logger. Salinity and concentrations of phosphate and nitrate in the substrate and the water column were also obtained at each visit. Nutrient concentration was analyzed by the general technique of flow injection analysis (FIA) by the MSI analytical Lab in the Marine Science Institute of the University of California, Santa Barbara. All variables were standardized and a correlation analysis was performed to select the variables for the Principal Component Analysis. Statistical analyses were performed with the STATISTICA software package (1999) using 0.95 confidence levels.

Results

Following Tabachnick and Fidell (2001) all variables whose correlations where less than ±0.30 were dropped from the PCA analysis since such correlations are not considered significant (Table 1).

We can see on Table 1 high negative correlation coefficients between abiotic variables and some biotic variables, which are contrary to values reported in the literature. Specifically, the negative correlation coefficient between temperature and biotic variables, is contrary to the reported positive correlations between variables (Aioi 1980; Ibarra-Obando and Huerta-Tamayo 1987; Solana et al. 1997; Ibarra-Obando et al. 1997). These high negative correlations might be due to a compounded lag effect on the meadow of a strong El Niño event that occurred during 1998, followed by an equally strong La Niña event that took take place in 1999.

The Scree analysis of eigenvalues (Cattell 1966) selected only three eigenvalues and, therefore, the PCA extracted three factors that together account for approximately 63% of the variability. Table 2 shows the loading of the extracted principal component (Marked loadings are >0.60). The first factor, which includes density and growth, accounted for 29% of the variability. The second factor, which accounted for 21% of the variability, consisted of temperature and radiation. A third factor consisted of nutrient concentration and accounted for 13% of the variability. This means that together the two abiotic factors accounted for 34% of the variability of all variables in the study. Density and biomass denotes the first factor and it counts for 29% of the variability.

Figure 1, displays the plot of variables in the component 2 (Temperature and Luminosity) versus component 3 (nutrients concentration) plane. Total biomass, number of nodes, age of shoots, number of leaves in shoots and above-ground biomass form a group that is determined equally by both factors. Meanwhile, shoot density, leaves inside shed, lateral shoots and new shoots, form another group which is determined by a linear combination of negative coefficient values of temperature and luminosity and positive coefficients of nutrient concentrations. The third group aggregates below-ground biomass and growth and is determined by low negative values of temperature and solar radiation (factor 2) and nutrient concentration (factor 3).

For the variables that compose the three principal components, we present a plot of the mean monthly values through the year of sampling, together with 1999 versus 2000 comparative tables of mean maximum and minimum values and the

Table 2. Factor loadings for principal component extraction and proportion of the explained variability of variables by each factors. See Table 1 for explanation of variable names.

Variables	Factor 1	Factor 2	Factor 3
SD	**0.64**	−0.50	0.13
AB	**0.93**	0.06	0.16
BB	**0.75**	−0.20	−0.10
TB	**0.91**	0.24	0.18
G	**0.84**	−0.18	−0.22
PH	−0.25	−0.23	**0.63**
N	0.30	0.14	**0.76**
NN	−0.58	0.29	0.38
PL	0.56	0.34	0.09
A	−0.50	0.39	0.40
LIS	−0.42	−0.49	0.07
LS	−0.30	−0.50	0.22
NLG	−0.14	−0.07	0.28
NS	−0.36	−0.44	0.35
MT	−0.05	**0.86**	−0.16
MNT	−0.54	**0.61**	0.007
AVT	0.009	**0.80**	0.04
UR	0.22	0.25	0.54
AR	0.49	**0.72**	0.30
S	−0.23	0.38	−0.48
Explained Variability	5.5	4.2	2.5
Proportion of Total Variability	0.28	0.21	0.13

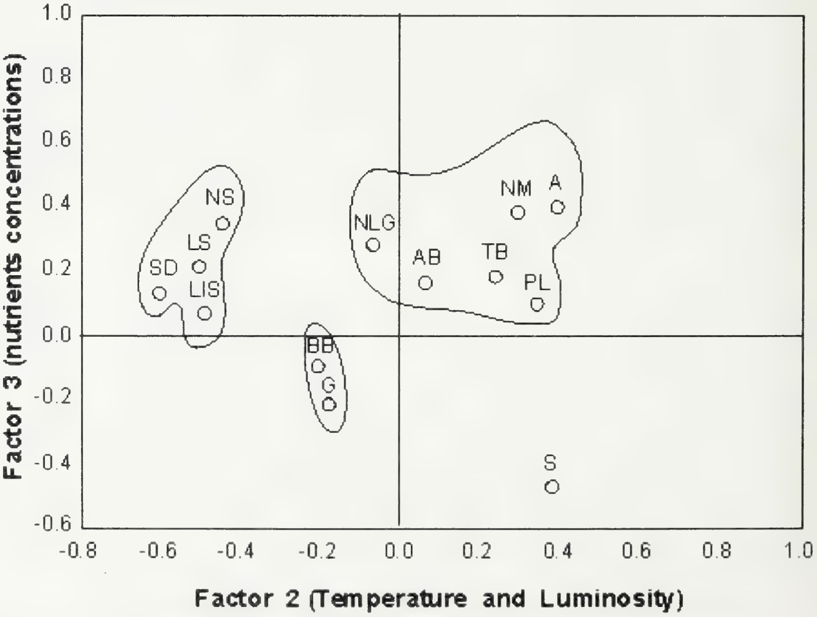
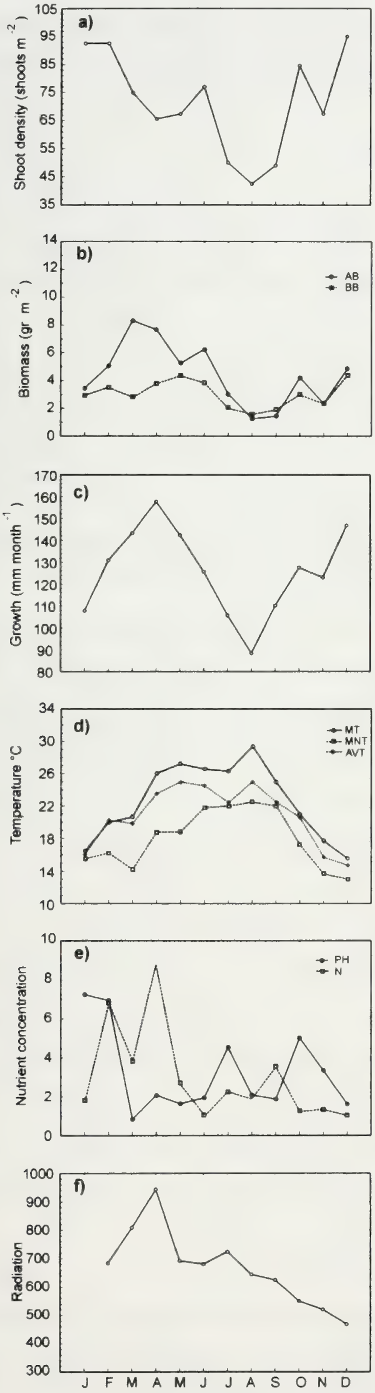


Fig. 1. Plot of variables in the factor 2 vs. Factor 3 plane. See Table 1 for explanation of variable names.



Variable	Mean	Year 1999	Month attained	Year 2000	Month attained
SD	Max	204	May	95	December
	Min	87	August	42	August

Variable	Mean	Year 1999	Month attained	Year 2000	Month attained
AB	Max	18.6	July	8.3	March
	Min	6.7	December	1.3	August
BB	Max	8.0	July	4.4	May & Dec.
	Min	2.5	November	1.6	August

Variable	Mean	Year 1999	Month attained	Year 2000	Month attained
G	Max	163.9	June	157.7	April
	Min	90.5	August	88.4	August

Variable	Mean	Year 1999	Month attained	Year 2000	Month attained
MT	Max	-	-	29.3	August
	Min	-	-	15.6	December
MNT	Max	-	-	22.5	August
	Min	-	-	13.1	December
AVT	Max	24	September	25	August
	Min	15	April	14.7	December

e) No data available for 1999

f) No data available for 1999

Fig. 2. Plot of mean monthly values of variables that compose the three principal components extracted from the analysis. Each graph is accompanied by a comparative table of mean maximum and minimum values and the month that those values were attained in 1999 and 2000 respectively.

month that those values were attained. The tables of Figure 2 show the differences between 1999 and 2000 for most variables with respect to the mean maximums and minimums as well as the months where those values were attained.

Discussion

As Short and Neckles (1999) point out, it is very difficult to predict how communities of seagrasses will be affected by global climate change. Since most variables that act on the growth dynamics of seagrasses are seasonally determined (Gallegos-Martinez et al. 1993, 1994; Olesen & Sand-Jensen 1994; Solana-Arellano 2002) changes in temperature and luminosity have an inherent effect in the dynamics of the meadow. Nevertheless, the impact of anomalous changes such as the increase of temperature above normal might, as Short and Neckles (1999) stated, change the plant community up to the point of changing its distribution through direct effects on flowering and seed germination. Moreover, Solana et al. (1997) point out that in virtue of the tolerance law, increasing temperature in sea water might give as a result sub optimum growth rates. Similarly decrease in superficial sea water temperatures result in growth rates higher than expected. Moreover, Rasmussen (1977) reported that for *Zostera marina* a high temperature stress over shoots is responsible for a negative growth.

The above arguments together with the fact that an strong EL Niño ENSO event took place in 1998 followed by an equally high La Niña event in 1999 sustain our suggestion that the highly negative correlation coefficients between most biotic variables and temperature (Table 1) as well as the high differences shown in figure 2, might be due to a compounded lag effect on the meadow of the above mentioned events and clearly support the Short and Neckles (1999) arguments in the sense that anomalous temperatures may change the dynamics of the meadow. The PCA analysis in the present work shows that light radiation, temperature and nutrient concentration are determining factors in *Zostera marina* meadows because they explain a significant amount of the variability in biotic variables (ca. 34%). Moreover, our study also shows how the considered biotic variables are determined by two principal factors. For example, from Table 2, we can easily see that variables such as total biomass (TB) and age (A) are equally determined by these PCA factors. Meanwhile, our results also show that the explained variability on mean node length has a greater contribution of nutrient concentration rather than temperature and luminosity. The knowledge of these causal relationships will help us to understand and explain and propose the pertinent models that can predict the processes that determine the dynamics of seagrass populations.

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References

Aioi K. 1980. Seasonal change in the standing crop of eelgrass (*Zostera marina* L) in Odawa Bay, Central Japan. Aquatic Botany 8:343–354.

den Hartog C. & Polderman P.J.G. 1975. Changes in The seagrass populations of the Dutch Waddenze. Aquatic Botany, 25:15–26.

Cattell R. B. 1966. The Scree test for the number of factors. Multivariate Behavioral Research I. 245–276.

Gallegos M., M. Merino, N. Marbá & C. Duarte. 1993. Biomass and Dynamics of *Thalassia testudinum* in the Mexican Caribbean: elucidating rhizome growth. Marine Ecology Progress Series. 95: 185–192.

———, M. Merino, A. Rodriguez, N. Marbá & C. Duarte. 1994. Growth patterns and demography of pioneer Caribbean seagrasses *Halodule wrightii* and *Syringodium filiforme K.* Marine Ecology Progress Series. 109:99–104.

Ibarra-Obando S.E. and R. Huerta-Tamayo 1987. Blade production of *Zostera marina* L. during the Summer–Autumn period on the Pacific coast of Mexico. Aquatic Botany 28:301–315.

———, C. Boudouresque & M. Roux 1997. Leaf dynamics and production of a *Zostera marina* bed near its southern distributional limit. Aquatic Botany 58:99–112.

Jacobs R.W.P.M., 1979. Distribution and aspects of the production and biomass of eelgrass (*Zostera marina)* beds. Aquatic Botany 7:151–172.

Olesen B. & K. Sand-Jensen 1994 Biomass-density patterns in the temperate seagrass *Zostera marina.* Marine Ecology Progress Series. 109:283–289.

Orth. R.J. & Moore K.A. 1986. Seasonal and year to year variation of the growth of *Zostera marina* L. (eelgrass) in the lower Chesapeake Bay. Aquatic Botany. 24:335–341.

Penhale P.A. 1977. Macrophyte-epiphyte biomass and productivity in an eelgrass (*Zostera marina* L) community. Journal of Experimental Marine Biology and Ecology 26:211–224.

Phillips, R.C. 1974. Transplantation of seagrasses, with special emphasis on eelgrass, *Zostera marina* L., Aquaculture. 4:161–176.

Rasmussen E. 1977. The wasting disease of eelgrass (Zostera marina) and its effects on enviromental factors and fauna In: *Seagrass ecosystems a scientific perspective.* C.P. McRoy & C. Helfrich editors. Marcel Dekker New York pp1–51.

Riggs, S.A. and Fralick R.A. 1975. *Zostera marina* L., its growth and distribution in Great Bay Estuary, New Hampshire, Rhodora 77:456–466.

Sand-Jensen, K, 1975. Biomass, net production and growth dynamics in an eelgrass (*Zostera marina. L.*) population in Vellerup Vig. Denmark. Ophelia 14:185–201.

Setchell, W. A. 1929. Morphological and Phenotypical notes on *Zostera marina* L. U. C., Pub. in Botany. 14:389–452.

Shepherd S.A., McComb A.j., Buthuis D.A., Neverauskas V., Steffensen D.A. & West R. 1989. Decline Of Seagrassess. In: Biology Of Seagrasses: A Treatise On The Biology Of Seagrasses With Special Reference to The Australian Region (eds. A.W. Larkum, A.J. McComb & S.A. Shepherd). Elsevier, Amsterdam. 346–393 pp.

Short F.T 1987. The effects of sediment nutrients on seagrasses: literature review and mesocosm experiment. Aquatic Botany 27:41–57.

Short F.T. and H.A. Neckles 1999. The effect of global climate change on seagrasses. Aquatic Botany 63:169–196.

Solana-Arellano E., H.A. Echavarria-Heras and S.E. Ibarra-Obando. 1997. Leaf size dynamics for *Zostera marina* L. in San Quintín Bay, Mexico: a theoretical study. Estuarine Coastal and Shelf Sciences. 44:351–359.

Solana-Arellano E., H. Echavarria-Heras and O. Flores-Uzeta 2000. An upgraded method to relocate marked shoots of the seagrass *Zostera marina.* Rev. Biol. Trop., 48(4)927–930.

Solana-Arellano E. 2002. Unpublished data.

Stearns S.C. 1992. The Evolution of Life Histories. Oxford University Press. Oxford New York. 243 pp.

Tabachnick B. And L. Fidell 2001. Using Multivariate statistics. By Allyn & Bacon A Pearson Education Company.

Zieman, J.C. 1968. A study of the growth and decomposition of the seagrass, *Thalassia testudinum.* MSc thesis University of Miami Florida. 50p.

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Tropical Fish Species as Indicator of 1997–1998 El Niño in Bahía de San Quintín, Baja California, México

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Abstract.—The 1997–1998 El Niño event was characterized by rapid development, strength, and record high sea-surface temperatures in the eastern equatorial Pacific. Mobile organisms such as fishes with a tropical distribution showed a shift northward reaching high latitudes. Bahía de San Quintín is a coastal lagoon in north Pacific, Baja California, México. Low temperatures caused by almost permanent upwelling, keeps lagoon temperature relatively low. However, the presence of four tropical fish species in this lagoon during the seasonal sampling of 1998 indicated an influence of a string El Niño event. The bigscale goatfish (*Pseudupeneus grandisquamis*), the white grunt (*Haemulopsis leuciscus*), the bullseye puffer (*Sphoeroides annulatus*), and the paloma pompano (*Trachinotus paitensis*) are species of tropical affinity that were present in this coastal lagoon.

The El Niño 1997–1998 phenomenon has been considered the largest event of the past century reaching from the Gulf of Alaska (Freeland 2000) to Perú (Sánchez et al. 2000). A great intensity beginning in 1997, and an abrupt collapse in 1998 characterized this event.

In Southern California coastal waters, El Niño effects were evident beginning in summer and fall 1997, and were strongest in winter 1997–1998 and spring 1998, based on northward range extensions of southern warm-water species of both fish and plankton (Hayward 2000). With the environmental changes, the fauna responded rapidly, and organisms distributed to the south had the ability to migrate or colonize more northern locales during this anomalous warm period, and resulted in temporal or permanent additions of species to our fauna (Pondella and Allen 2001). During this period, members of 29 families of Panamic fishes were recorded from California waters, and ten of those were reported as new or first records from the warm-temperate or San Diegan biogeographical region of the eastern North Pacific (Lea and Rosenblatt 2000).

Along the coast of Baja California, the oceanographic evolution of 1997–1998 El Niño, and the transition to La Niña 1999, registered up to 8.7°C warmer and S = 0.8 saltier (Durazo and Baumgartner 2002), and anomalies persisted from 1997 through January 1998. The plankton response was atypical, with normal values in 1997–1998 (chlorophyll *a*: 27 mg/m^3; zooplankton displacement volumes 100 ml/1000 m^3), and after the peak of El Niño, the system shifted to cooler conditions and chlorophyll gradually increased to a media of 77 mg/m^3 in April 1999, but in contrast zooplankton volumes decreased from october 1998 onward, despite favorable phytoplankton availability in 1999 (Lavaniegos *et al.* 2002).

Bahía de San Quintín is a coastal lagoon located on the Pacific coast of North Baja California, México about 300 km south of the California border (30°24′–30°30′ N, 115°57′–116°01′ W), and is one of the most important sites for fish recruitment and dispersion (Rosales-Casián 1997a,b). With a total area of 4,000 ha. The lagoon is divided into two arms: Bahía Falsa forms the western arm and, Bahía de San Quintín the eastern branch. Bahía Falsa is a shallow site with an extensive oyster culture, and the San Quintín arm is the main body of water with a channel up to 15 m deep. This site communicates with the sea through a narrow (<1000 m wide) mouth that is 2–7 m deep. It is considered a high productivity habitat by the presence of extensive eelgrass beds and phytoplankton. The lagoon is characterized by an almost permanent upwelling close to the mouth, forming an unique environment with usually low temperatures.

Fish collections conducted in San Quintín from 1993 to 1995 (monthly in 1994), showed a typical temperate fish community (Rosales-Casián 1996). However, during our 1998 seasonal collections in the San Quintín arm, we identified fish species not found in other years. The salmonete or bigscale goatfish (*Pseudupeneus grandisquamis*), burrito or white grunt (*Haemulopsis leuciscus*), botete or bullseye puffer (*Sphoeroides annulatus*), and pampano or paloma pompano (*Trachinotus paitensis*) are species of tropical affinity that were present in this coastal lagoon.

Four individuals of the bigscale goatfish were collected with a 7.5-m wide semiballon otter trawl (10 m length with 19 mm mesh in body, 5 mm in bag end), during 5 min tows at an approximate speed of 2.0 knots. The first three individuals were collected in the first tow of four replicates at 5 m-depth (30°28′4″ N–115°57′9″ W), and the fourth specimen on the second replicate (30°27′2″ N–115°57′6″ W). Collection date was March 30th, 1998 at 13:36 and 13:47 hours, respectively. Surface temperature were 17.2 and 17.1°C, and 5 m-bottom temperature were 17.0 and 17.1°C, respectively. Those fish were first thought to be mexican goatfish (*Mulloidichthys dentatus*). However, they were later identified as bigscale goatfish by Robert N. Lea. One specimen was deposited at Scripps Institution of Oceanography (SIO-00-12). Total-standard lengths (mm), and weights (gr) were: 148-114, 40.2; 158-128, 53.5; 152-118, 44.0; 146-116, 44.0, respectively.

One individual juvenile of the white grunt was collected in the same second replicate of the otter-trawl tow in March 30th, 1998; the record of this species was a northward range extension and has been reported before (Rosales-Casián and Ruiz-Campos 1999). The individual was compared with samples from the collection of CICIMAR at La Paz, Baja California, México, and it's identify was verified by José de la Cruz-Aguero. The specimen (118 mm LT–94 mm SL, 23 g) was deposited in the fish collection of the Facultad de Ciencias, Universidad Autónoma de Baja California, catalog number UABC-874. This species is a common benthic inhabitant of tropical coastal waters and has a low fishery importance (Amezcua-Linares 1996). The previously known northernmost distribution of the white grunt was Bahía Magdalena (Puerto Lopez Mateos) on the western coast of Baja California (De La Cruz-Aguero *et al.* 1994) and Bahía Concepción in the Gulf of California (De la Cruz-Aguero 1997).

A bullseye puffer was captured with the same otter-trawl in the second replicate on 5 m-depth, on May 22nd, 1998. The specimen has 340 mm LT, 280 mm SL, and weighed 907 g. This puffer is reported as ranging from San Diego, CA (USA) to Galapagos Islands (Miller and Lea 1972), but it is rare north of Bahía Magdalena (Fitch and Lavenber 1975). In a coincident sampling trip to Bahía de San Quintín with us, an individual of this species was collected with otter-trawl in May 4th, 1993 by students of the Facultad de Ciencias Marinas, Universidad Autónoma de Baja California, but not saved; this specimen can be an indicator of the 1992–1993 El Niño.

Another tropical species collected at Bahía de San Quintín was the paloma pompano. Two individuals of this species (256 mm TL–194 mm SL, 208 g; 246 mm–180 mm, 176g) were captured in the third replicate (30°27′3″ N, 115°57′4″ W) of otter-trawl tow on 5 m-depth (September 30th, 10:05 hour, temperature 21°C surface, 20.9 bottom), and were verifying by Robert N. Lea. The specimens remain in our collection at CICESE.

The seasonal sampling at Bahía de San Quintín included the use of nets (otter-trawl, beam-trawl, beach seine, gillnet), and hook-and-line with replicate tows at depths of <2.5, 5 and 10 m; however, only the otter-trawl collected those warm-water fish species. Also, we collected these species in 5 m, over a bottom characterized by dense eelgrass (*Zostera marina*) beds. We did not make additional collections of those fishes during a December 1998 sampling.

It is likely that the normally low temperatures of this habitat limits the presence of warm-water fish species at Bahía de San Quintín; during the 1998 El Niño we also captured the spotted sand bass (*Paralabrax maculatofasciatus*), the kelp bass (*Paralabrax clathratus*), and the salema (*Xenistius californiensis*), fish species not captured during cold years 1994–1995. The presence of the four tropical fish species in Bahía de San Quintín clearly shows the effect of 1997–1998 El Niño. This El Niño at least increased temporarily the fish species richness in this coastal lagoon.

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Literature Cited

Amezcua-Linares, F. 1996. Peces demersales de la plataforma continental del Pacífico Central de México. Instituto de Ciencias del Mar y Limnología-UNAM and Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, México. 184 pp.

De La Cruz-Aguero, J., F. Galván-Magaña, L. Abitia-Cárdenas, J. Rodriguez-Romero, and F.J. Gutierrez-Sánchez. 1994. Lista sistemática de los peces marinos de Bahía Magdalena, Baja California Sur, México. Ciencias Marinas, 20:17–31.

De la Cruz-Aguero, J., M. Arellano Martinez, V.M. Cota-Gómez, and G. De La Cruz-Aguero. 1997. Catálogo de los peces marinos de Baja California Sur. Centro Interdisciplinario de Ciencias Marinas-IPN and Comisión Nacional para el Conocimiento y Uso de la Biodiversidad, México. 341 pp.

Durazo, R. and T.R. Baumgartner. 2002. Evolution of oceanographic conditions off Baja California: 1997–1999. Progress in Oceanography 54:7–31.

Fitch, J.E. and R.J. Lavenberg. 1975. Tidepool and nearshore fishes of California. California Natural History Guides: 38. Univ. Calif. Press. 156 p.

Freeland, H. 2000. The 1997–98 El Niño: The view from line-P. CalCOFI Rep. 41:56–61.

Hayward, T.L. 2000. El Niño 1997–98 in the coastal waters of Southern California: A timeless of events. CalCOFI Rep. 41:87–116.

Lavaniegos, B.E., L.C. Jiménez-Pérez, and G. Gaxiola-Castro. 2002. Plankton response to El Niño 1997–1998 and La Niña 1999 in the southern región of the California current. Progress in Oceanography 54:33–58.

Lea, R.N. and R.H. Rosenblatt. 2000. Observations on fishes associated with the 1997–98 El Niño off California. CalCOFI Rep. 41:117–129.

Pondella, D.J. and M.J. Allen. 2001. Proceedings of special symposium: New and rare fish and invertebrate species to California during the 1997–1998 El Niño. Bull. So. Calif. Acad. Sci. 100(3):129–130.

Rosales-Casián, J.A. 1996. Ichthyofauna of Bahía de San Quintín, Baja California, México, and its adjacent coast. Ciencias Marinas 22:443–458.

Rosales-Casián, J.A. 1997a. Inshore soft-bottom fishes of two coastal lagoons on the northern Pacific coast of Baja California. CalCOFI Rep. 38, 180–192.

Rosales-Casián, J.A. 1997b. Estructura de la comunidad de peces y el uso de los ambientes de Bahías, lagunas y costa abierta en el Pacífico norte de Baja California. PhD thesis, Ecología Marina, CICESE. 201 p.

Rosales-Casián, J.A. and G. Ruiz-Campos. 1999. Northern range extension of the white grunt, *Haemulopsis leuciscus.* Calif. Dept. Fish and Game 85(3):135–137.

Sánchez, G., R. Caliens and S. Zuta. 2000. The 1997–98 El Niño and its effects on the coastal marine ecosystem off Peru. CalCOFI Rep. 41:62–86.

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The Spray Nozzle of the Bombardier Beetle, *Brachinus favicollis* Erwin

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Abstract.—The Bombardier beetle (*Brachinus* sp., *Metrius* sp., *Stenaptinus* sp.) has been often studied due to its ability to synthesize and spray a hot, noxious combination of benzoquinones and oxygen. Abdomens of *Brachinus favicollis* collected in Santa Clarita, Los Angeles County, California, were studied under transmission and scanning electron microscopy. The spray nozzle is shown to be more complex than previously reported. Bacteria were found in the lumen of the secretory lobes, but not in digestive structures.

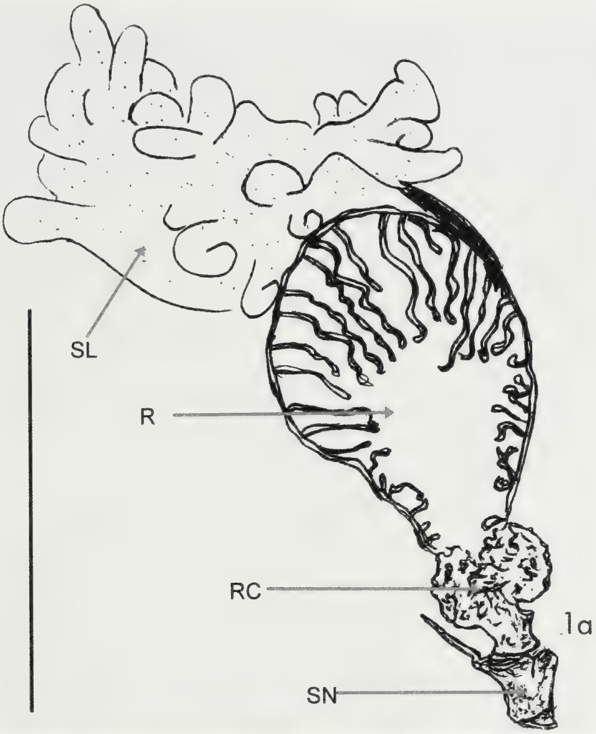
The bombardier beetle has been a subject of interest for many years. It is called a "bombardier" because it ejects a hot, highly noxious spray of aqueous benzoquinones, oxygen, and steam as a defense mechanism against would-be predators (Aneshansley et al. 1969, 1983; Blum 1981; Crowson 1981; Eisner 1958, 1970; Eisner and Aneshansley 1982, 1999; Eisner et al. 1977, 1992, 2000; Forsyth 1972; Schildknecht and Holubek 1961; Schildknecht et al. 1970; Schnepf et al. 1969). This secretion is accurately delivered via twin spray nozzles emanating from the tip of the beetle abdomen (Figure 1a, b) and is most effective at stunning predators including mammals such as mice, thus allowing the beetle to escape (Eisner 1958).

Bombardier beetles range in size from 2.0 mm overall length (*Mastax*) to 30 mm in length (*Aptinomorphus*) and can be found all over the world, from the United States and Mexico to Australia (Erwin 1970). They live under rocks or pebbles in cool, sandy soil, usually near a stream or a lake. Aggregating in groups during the daytime, they are usually active at night.

There exist several different types of bombardier beetles, which employ somewhat different types of defensive structures and chemistry but generally the same method of defense—spraying at predators when threatened and then running away. One tribe, however, (Mystropomini), is known to bury itself in the ground with only its abdominal tip above the ground (Eisner et al. 1992). Most bombardier beetles exist in the family Carabidae, and within that family are three subfamilies: Brachinae, Metriinae, and Paussinae (Aneshansley et al. 1983).

O. J. Westwood interviewed a traveler returning from South America, and wrote that large beetles of the genus *Brachinus* "on being seized . . . immediately . . . play off their artillery, burning . . . the flesh to such a degree, that only a few specimens (can) be captured with the naked hand" (Aneshansley et al. 1969).

Workers have found that the spray is ejected in explosive discharges of about 500 pulses per second (Dean et al. 1990), which can surprise and deter large vertebrates (frogs) (Aneshansley et al. 1969; Blum 1981; Dean 1980; Dean et al. 1990; Eisner 1958, 1970). Some predators even experience seizures (Eisner 1958). Toads can sometimes capture caustic arthropods (millipedes and other beetles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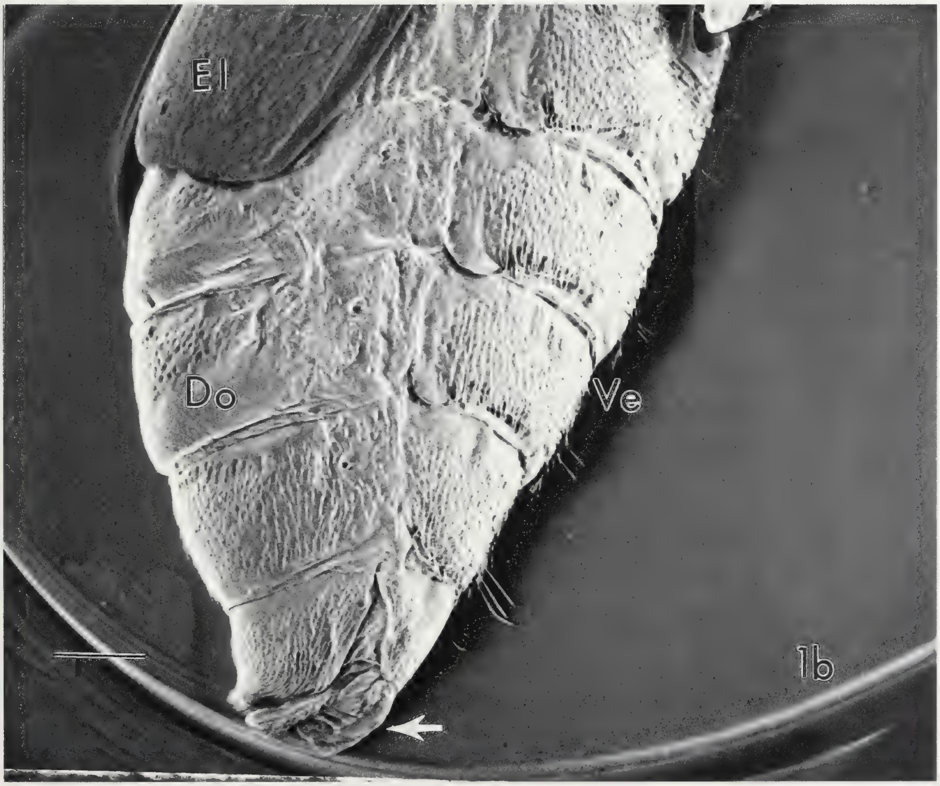
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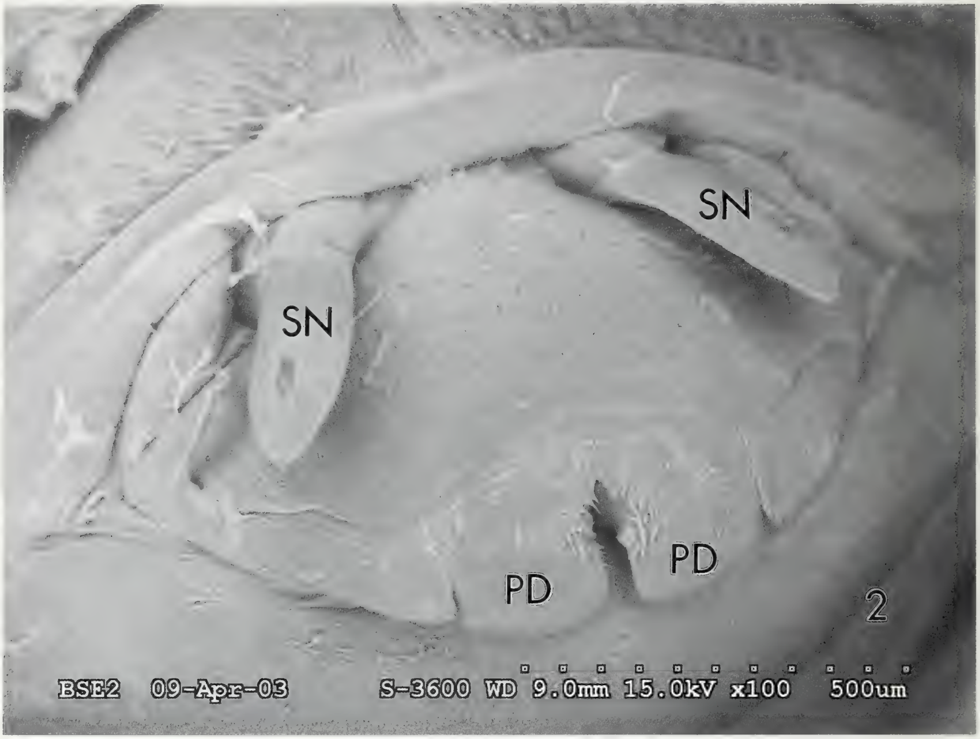

Fig. 2. Paired spray nozzles (SN) and paired deflection paddles (PD). Scale bar = 0.5mm.

which secrete noxious substances) because a rapid flick of their tongue allows them to grab and swallow before the arthropod can take action (Eisner and Meinwald 1966). However, bombardier beetles are able to discharge their spray in as little as 90 milliseconds when sufficiently provoked, thus evading capture by toads (Dean et al. 1990). One study records the velocity of the spray to be within a range of 325 to 1950 cm/s (Ibid).

Additionally, the beetle's spray is boiling hot (100°C), a feature that seems to be dependent on the biochemistry between the reactants (hydroquinones and hydrogen peroxides that the beetle synthesizes and stores in the reservoirs), and the enzymes (catalases and peroxidases that are added to the reactants in the reaction chamber) (Aneshansley et al. 1969, 1983; Dean et al. 1990; Eisner 1970; Eisner et al. 1977, 2000; Nakatani et al. 1996; Schildknecht and Holubek 1961).

Structure

The structure of the defense system of the bombardier beetle is complex, consisting of twin, bilateral sets of secretory lobes, which connect via long tubes to

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Fig. 1a. Left side of the pygidial gland of the bombardier beetle (after Forsyth 1972). SL = secretory lobe, R = reservoir, RC = reaction chamber, SN = spray nozzle, scale bar = 1.0mm.

Fig. 1b. Abdomen of intact beetle. White arrow points to the tip where the spray is ejected. El = elytra, Do = dorsal side, Ve = ventral side, scale bar = 4.0mm.

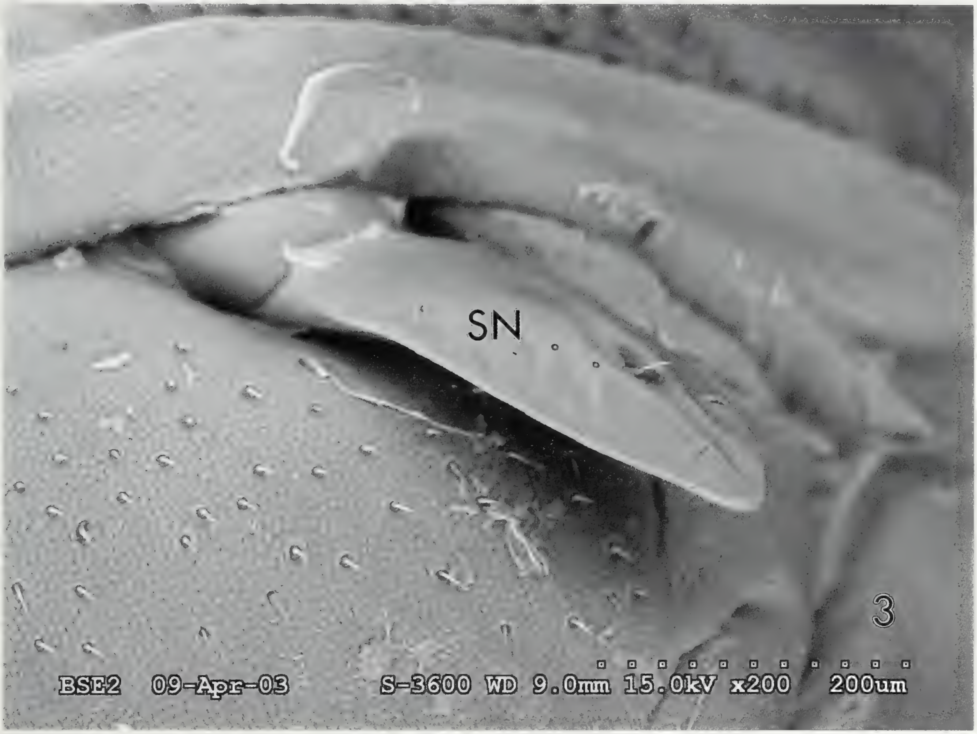

Fig. 3. Tongue-like spray nozzle (SN). Scale dots = 200 microns.

collecting reservoirs, (each of which is surrounded by a thin layer of muscle). Additionally there are one-way valves, sphincter muscles, reaction chambers, exit tubes, and exit nozzles (Figure 1a) (Aneshansley et al. 1969, 1983; Crowson 1981; Dean et al. 1990; Eisner 1970; Eisner et al. 2000; Schnepf et al. 1969).

Each secretory lobe secretes aqueous hydrogen peroxide and hydroquinones, which are stored in large quantity in the collecting reservoirs. It is reported that the same cells actually synthesize and separate both the hydrogen peroxide and the hydroquinones (Schnepf et al. 1969). The stored liquids remain in the full reservoirs until needed. Each collecting reservoir is joined to a reaction chamber by means of a one-way valve controlled by a sphincter muscle (Aneshansley et al. 1969; Crowson 1981; Eisner 1970; Schnepf et al. 1969). One study, however (Dean et al. 1990) suggests that the valve itself oscillates passively, in an automatic fashion. That report maintains that the collection reservoir, the valve, and the reaction chamber function together to work as a "pulse jet," with the spray emitted in pulses. Using a microphone, force transducer (piezoelectric crystal), and high-speed cinematography, workers discovered that each discharge (lasting 2.6 to 24.1 ms) consists of 2 to 12 individual pulses, and that they are in reality individual micro-explosions repeating at 368 to 735 pulses per second within the reaction chamber [ibid]. All known carabid "bombardier" beetles have internal spray structures similar to this, and they all employ a similar chemical reaction (Aneshansley et al. 1983).

When the bombardier beetle is threatened (such as with a bite on the limb) it

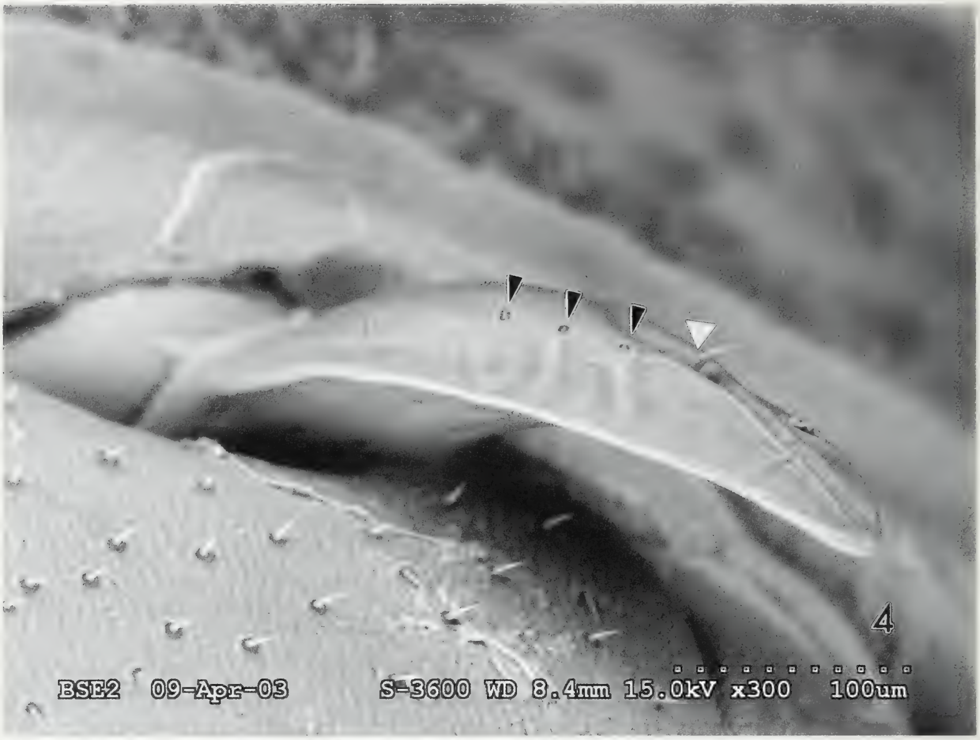

Fig. 4. Close up of spray nozzle with small pores (black arrows) and large pore (white arrow). Scale dots = 100 microns.

contracts its collection reservoirs, moving the hydrogen peroxide and hydroquinones into the reaction chamber through the valves. The reaction chambers are reported to be lined with enzyme-secreting cells, which produce peroxidases and catylases (Aneshansley et al. 1969; Crowson 1981; Schnepf et al. 1969), although some studies state that oxidases and other enzymes are secreted and kept stored in the reaction chamber (Dean et al. 1990; Eisner 1970).

When the hydrogen peroxide and hydroquinones come into contact with the enzymes, an explosive reaction takes place, yielding water, quinones, heat and gaseous oxygen. The pressure of the free oxygen propels the mixture out of the reaction chambers and through the spray nozzles, directed to the target (either at the predator or on the beetle's own integument as a protective measure).

Forsyth (1972) describes the spray nozzle as a "gaping aperture," at the ninth tergite (a plate of abdominal cuticle), or as a "short membranous tube" in different species of bombardier beetles. The results of the present study show that this structure is far from merely a short membranous tube or gaping aperture.

Additionally, the bombardier beetle has the ability to direct its defensive spray toward its aggressor very accurately. Several bombardier beetles (most notably Brachinini) show the ability to direct their spray in almost any direction, accurately enough to target different limbs (what the attacker usually bites or grasps), as well as different leg segments of the same limb (Dean et al. 1990; Eisner 1970; Eisner and Aneshansley 1999).

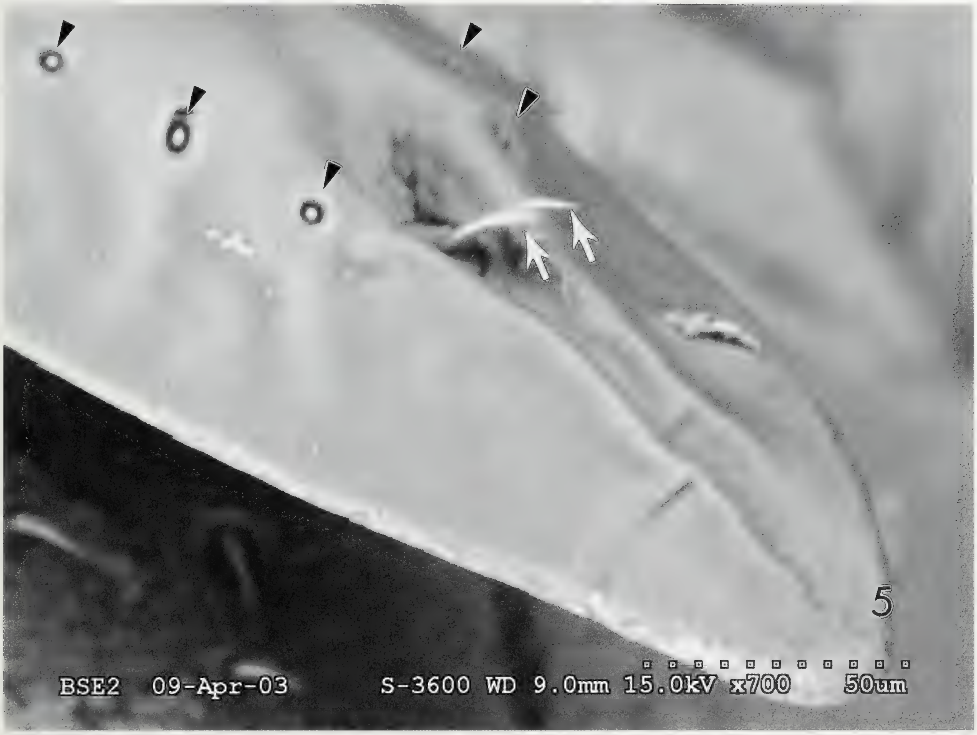

Fig. 5. Spray nozzle with clearly visible papillae (white arrows) and apertures on opposing side (black arrows). Scale dots = 50 microns.

The flexible abdominal tip of *Brachinus* can bend around in all directions even spraying directly forward, in an anterior direction over the dorsal surface, with help from special deflection plates or paddles (Dean et al. 1990; Eisner and Aneshansley 1999). These hardened cuticular plates, acting as deflectors, are located just outside the opening of the reaction chamber, and give directional control to the discharge by changing their angle of deflection. Exactly how these deflectors are used to direct the spray is not understood. The spray of beetles in the tribe Brachinini, has been shown to deter several natural predators (Crowson 1981; Eisner 1958, 1970; Eisner and Aneshansley 1999). These include the ant *Pogonomyrmex badius,* which "retreated swiftly," and commenced to have a series of "short, intermittent seizures, abrupt in onset, during which the legs stretched outward and flailed ineffectually against the substratum, greatly hampering and often completely stalling forward movement" (Eisner 1958).

Also observed to be deterred was the beetle *Galerita janus,* which when sprayed, fled "hastily for a few centimeters, it suddenly became sluggish and circled aimlessly . . ." (Eisner 1958). In addition, the spray was also effective against the praying mantis, *Hierodula patellifera* and the spider, *Lycosa helluo* which was "brought to a sudden halt."

Materials and Methods

Twenty *Brachinus favicollis* Erwin were collected by hand from underneath rocks lying along a streambed in Santa Clarita, Los Angeles County, California.

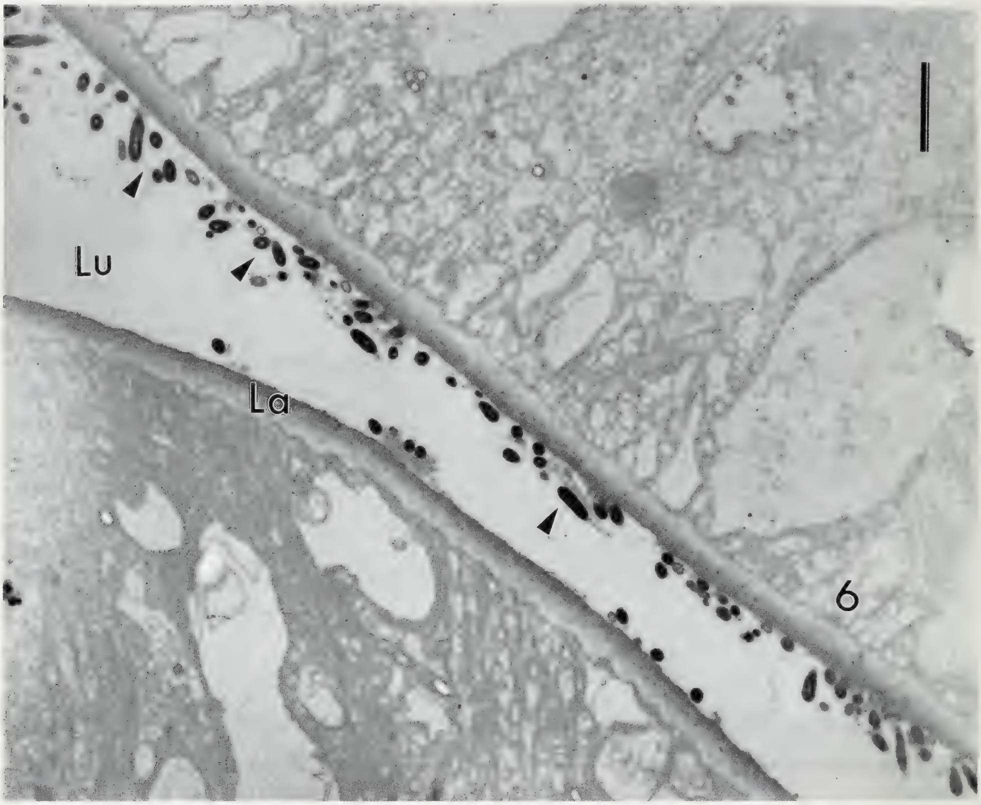

Fig. 6. Lumen (Lu) of secretory lobe populated with many bacteria (black arrows), La = chitinized lamella. Scale bar = 4.0 microns.

Beetles were observed to congregate in tightly knit groups until disturbed and then would scurry in all directions. Beetles fired their spray when captured and left fingertips blackened. They were kept in covered, 12″ diameter glass Stenner dishes in the laboratory and were sustained by bits of chicken and water-soaked paper towel for a year. Beetles calmed significantly over time in captivity to the point that they rarely fired their spray when nudged by finger, and they would often mill around when disturbed rather than run and hide.

Ten beetles were prepared for Scanning Electron Microscopy (SEM) by cooling on ice and immersion into cold 2% glutaraldehyde buffered in 0.2 M sodium cacodylate for 36 hours. Abdomens of fixed material were washed in water and buffer and were passed through a graded series of acetone assisted by microwave radiation in a laboratory microwave oven (Ted Pella, Inc, Redding, CA.). Dehydrated material was left in tetramethylsilane overnight, allowed to air dry, and then was sputter coated in gold and observed on a JEOL 35 SEM. Other fresh material was viewed and photographed unprocessed on a variable pressure, Hitachi S-3600 SEM.

Four beetles were prepared for Transmission Electron Microscopy (TEM) similarly, except they were postfixed in 2% osmium, then washed and dehydrated. Complete, dehydrated abdomens were infiltrated and embedded in Epon-Spurrs

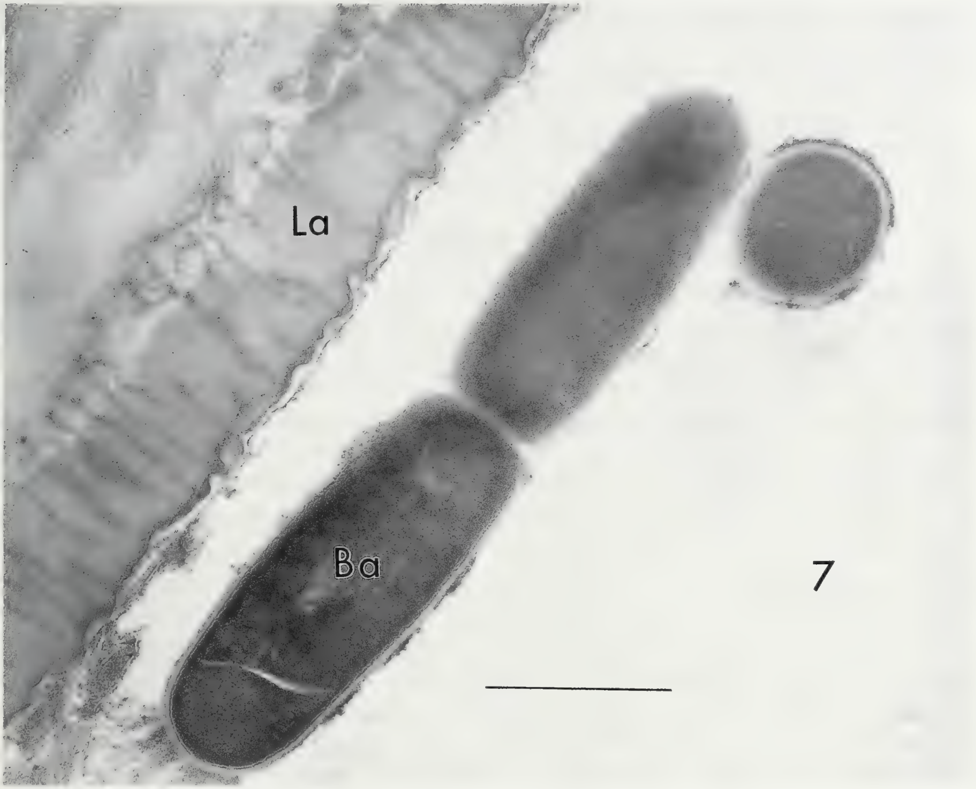

Fig. 7. Rod-shaped bacteria (Ba) adjacent to the chitinized lamella (La) of the secretory lobe wall. Scale bar = 1.0 micron.

resin in the microwave oven, and silver sections were collected, stained and viewed on a Zeiss 10C TEM.

Results

The nozzle of *Brachinus* is different from any description heretofore presented in the literature on this or other genera. Extending from the abdominal tip on either side of the tip are tongue-like projections (Figure 2), which upon closer examination reveal a pattern of apertures used for spray dispersal (Figures 4–6). A large pore is embedded at the tip of the nozzle containing flattened hairs or papillae that extend out of the pore and above the surface of the nozzle (Figures 3–5). Additionally, four or more smaller pores run along either side of the midline of the tongue-like nozzle, each with a small papilla extending from the center of the pore (Figure 4). Some nozzles had fewer small pores but all of them had at least 3 along either side of the midline. These pores and papillae are previously unreported. Paddle deflectors, described by other workers, are evident (Figure 2). Internal structures such as the secretory lobes, which synthesize hydroquinones and hydrogen peroxide, were well preserved, as was some of the secreted material. The collecting stalks and collecting lumens were also clearly visible. The inner walls of the secretary lobes are lined with thickly laid down layers of chitinized lamella (previously unreported), which have a coarsely grained, undulating outer margin (Figure 6).

The presence of many rod-shaped bacteria within the lumen of the secretory lobes (Figures 6, 7) adhering to or adjacent to the chitinized lamella is also reported for the first time. Bacteria were present in large numbers in that structure alone, and not in the ventriculus (or digestive structure) as expected.

Discussion

As discussed, this bombardier beetle has a particularly high accuracy for hitting its intended target. This accuracy could certainly be as a result of employing the paddle deflectors and highly flexible abdominal tip, but the muscular eversible spray nozzle with hydrodynamic pores as shown here may serve to achieve accuracy. It is not clear if the spray emanates from the large pore at the tip, or from all pores simultaneously, but it is suspected that all are employed. The remarkable photographic evidence of the aiming capability of *Stenaptinus insignis* reported by Eisner et al. (1999) shows a dispersed-spray emerging from the abdominal tip of the beetle, and not as if ejected from a pin-point source or aperture. Thus the nozzle pores and hair-like papillae, newly reported here, could account for the dispersal of the spray at the abdominal tip.

The discovery of bacteria in the lumen of the secretory lobes might indicate a symbiotic relationship between the bacteria and the beetle. However, it cannot be discounted that these bacteria might not exist within the secretory lobes of beetles in the wild. Bacteria found in this study could be related to the unnatural diet and habitat maintained during long captivity. More work is needed to understand the function of the bacteria within these structures.

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Literature Cited

Aneshansley, D.J., T. Eisner, J.M. Widom, and B. Widom. 1969. Biochemistry at 100° C: explosive secretory discharge of bombardier beetles (*Brachinus*). *Science* 165: 61–63.

Aneshansley, D.J., T.H. Jones, D. Alsop, J. Meinwald, and T. Eisner. 1983. Thermal concomitants and biochemistry of the explosive discharge mechanism of some little known bombardier beetles. *Experientia* 39: 366–368.

Blum, M.S. 1981. *Chemical Defenses of Arthropods.* Academic Press: New York.

Crowson, R.A. 1981. *The Biology of the Coleoptera.* Academic Press: New York.

Dean, J. 1980. Encounters Between Bombardier Beetles and Two Species of Toads (*Bufo americanus, Bufo marinus*): Speed of Spray Capture Does not Determine Success. *J. Comp. Phys.* 135: 41–50.

Dean, J., D.J. Aneshansley, H.E. Edgerton, and T. Eisner. 1990. Defensive spray of the bombardier beetle: a biological pulse jet. *Science* 248: 1219–1221.

Eisner, T. 1958. The protective role of the spray mechanism of the bombardier beetle, *Brachynus ballistarius. J. Insect Phys.* 2: 215–220.

Eisner, T. 1970. Chemical Defense Against Predation in Arthropods (in) *Chemical Ecology,* (Eds. E. Sondheimer, and J.B. Simeone), Academic Press: New York.

Eisner, T., and D.J. Aneshansley. 1982. Spray Aiming in Bombardier Beetles: Jet deflection by the Coanda Effect. *Science* 215: 83–85.

Eisner, T., and D.J. Aneshansley. 1999. Spray aiming in the bombardier beetle: Photographic evidence. *Proc. Nat. Acad. Sci.* 96: 9705–9709.

Eisner, T., D.J. Aneshansley, M. Eisner, A.B. Attygalle, D.W. Alsop, and J. Meinwald. 2000. Spray mechanism of the most primitive bombardier beetle (*Metrius contractus*). *J. Exp. Biol.* 203: 1265–1275.

Eisner, T., A.B. Attygalle, M. Eisner, D.J. Aneshansley, and J. Meinwald. 1992. Chemical Defense of a primitive Australian Bombardier Beetle: *Mystropomus regularis. Chemoecology* 2: 29–34.

Eisner, T., T.H. Jones, D.J. Aneshansley, W.R. Tschinkel, R.E. Silberglied, and J. Meinwald, J. 1977. Chemistry of defensive secretions of bombardier beetles (Brachanini, Metriini, Ozaenini, Paussini). *J. Insect Phys.* 23: 1383–1386.

Eisner, T. and J. Meinwald. 1966. Defensive Secretions of Arthropods. Insects, Millepedes, and Some of their Relatives Discharge Noxious Secretions That Repel Their Predators. *Science* 153: 1341–1350.

Erwin, T. 1970. A Reclassification of Bombardier Beetles and a Taxonomic Revision of the North and Middle American Species (Carabidae: Brachinida). *Quaestiones Entomologicae* 6: 4–215.

Forsyth, D.J. 1972. The Structure of the Pygidial Defence Glands of Carabidae (Coleoptera), *Trans. Zool. Soc. London*, 32: 249–309.

Nakatani, H.S., N.G. de Oliveira, O.E. Godinho, L.M. Aleixo, and K. Zinner. 1996. Bombardier beetle based biosensor. *Biosensors and Bioelectronics.* 11: 489–492.

Schildknecht, H., and K. Holoubek. 1961. Die bombardierkäfer und ihre explosionschemie. *Angewandte Chemie* 73(1): 1–7.

Schildknecht, H., E. Maschwitz, and U. Maschwitz. 1970. Die explosionschemie der bombardierkäfer: struktur und eigenschaften der brennkammerenzyme. *J. Insect Phys.* 16(4): 749–789.

Schnepf, E., W. Wenneis, and H. Schildknecht. 1969. On the defense substances of arthropods. The chemistry of the bombardier beetle (Coleoptera, Carabidae) IV. The fine structure of the defensive glands of *Brachynus crepitans. Zeitschrift fëur Zellforschung und mikroskopische Anatomie.* 96: 582–599.

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Observations of the Acoustic Behavior of *Hoplosphyrum boreale* (Scudder): A Common Scaly Cricket of Southern California

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Abstract.—We describe observations of the acoustic behavior of the scaly cricket *Hoplosphyrum boreale* (Scudder), a common scaly-cricket (Orthoptera: Gryllidae: Mogoplistinae) of southern California and the desert southwest. The long-range calling song used by males to attract females from a distance is compared to song produced in close-range courtship interactions between males and females. We also describe preliminary observations of mating behavior, and the song of a sympatric undescribed species.

In comparison to field crickets (Orthoptera: Gryllidae: Gryllinae), ground crickets (Orthoptera: Gryllidae: Nemobiinae), and tree crickets (Orthoptera: Gryllidae: Oecanthinae), the acoustics and behavior of scaly crickets have received little attention. Scaly crickets are so named because small 'scales' cover nearly the entire body surface (Love & Walker 1979; Yang & Yen 2001). Although there are approximately 276 valid species currently recognized in 26 genera worldwide (Otte et al. 2002), other than taxonomic descriptions, there has been almost no ecological, evolutionary, or behavioral work done on this subfamily. Exceptions include Dambach and colleagues' behavioral and bioacoustic studies of an old world species *Cycloptiloides canariensis* (Dambach & Beck 1990; Dambach & Gras 1995) and Andrade & Mason's (2000) study of mating behavior in an Australian species, *Ornebius aperta.* The lack of attention paid this group of crickets probably reflects both their primarily pan-tropical and pan-subtropical diversification, as well as their occurrence in habitats that are "personally uncomfortable, physically impenetrable, or visually confusing to the collector" (Love & Walker 1979, p. 3). Fortunately, such is not the case in southern California, where *Hoplosphyrum boreale* (Scudder) is found in abundance in grassland and oak woodland habitats. In an effort to add to the knowledge of this group, we conducted field and laboratory observations of *H. boreale. H. boreale* is a small (ca. 1 cm length) brownish-gray colored cricket that inhabits the desert southwest (Fig. 1). Both sexes have a deep reddish-brown pronotum and head (Figs. 2A and B). Males have short wings covering nearly ⅓ of the abdomen. The wings are used to produce song to attract females for mating; females are wingless and do not produce song. The songs of other North American species of scaly crickets have been described in detail previously (Love & Walker 1979), however Love and Walker limited their detailed study to species found east of the 94th meridian. Thus the acoustic behavior of *H. boreale* and of a closely related, but as of yet undescribed species, has never before been published. The undescribed species

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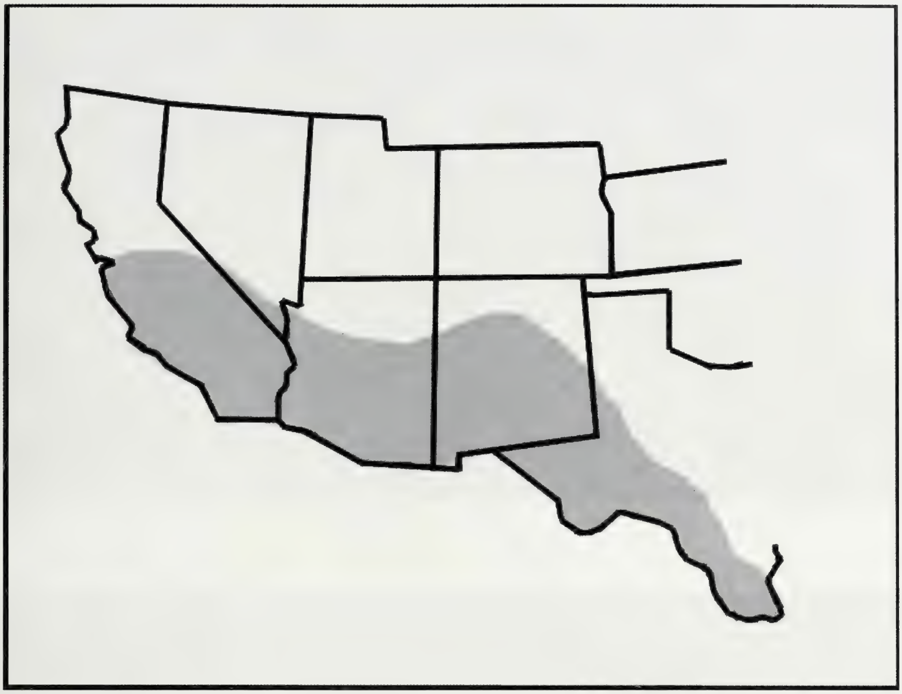

Fig. 1. Approximate geographic distribution of *Hoplosphyrum boreale* (redrawn from Walker & Moore 2002).

also occurs within our study area. Here we confirm its existence, and include a description of its song, but do not formally describe and name the species as taxonomic work is forthcoming (R. E. Love, personal communication 2002).

Methods and Results

Males and females were observed and collected in the fall of 2001 and 2002 at the Las Virgenes View Park (North 34° 6′, West 118° 43′) in the Santa Monica Mountains National Recreation Area, Los Angeles County, California. Collections were made under permit SAMO-2001-SCI-0011 from the United States Department of the Interior, National Park Service to D. A. Gray. Collected individuals were brought to the laboratory at California State University, Northridge where further sound recording and behavioral observations were made. Crickets in the laboratory were held individually in 500 ml containers provided with food (Purina cat chow, Ralston Purina, St. Louis, MO) and water continuously available in cotton-plugged vials.

General Observations.

We have observed *Hoplosphyrum boreale* in grassland and mixed oak woodland areas. *H. boreale* produces a distinctive calling song consisting of a series of chirps normally composed of 2 to 3 pulses per chirp (Figs. 3 and 4). Cracks in the soil are used as refuges during the daytime hours, and to a lesser extent at night. In the evening and nighttime, males call from cracks in the soil as is common with field crickets in the genus *Gryllus*. However, males and females are both very mobile and are very frequently seen walking aboveground, presum-

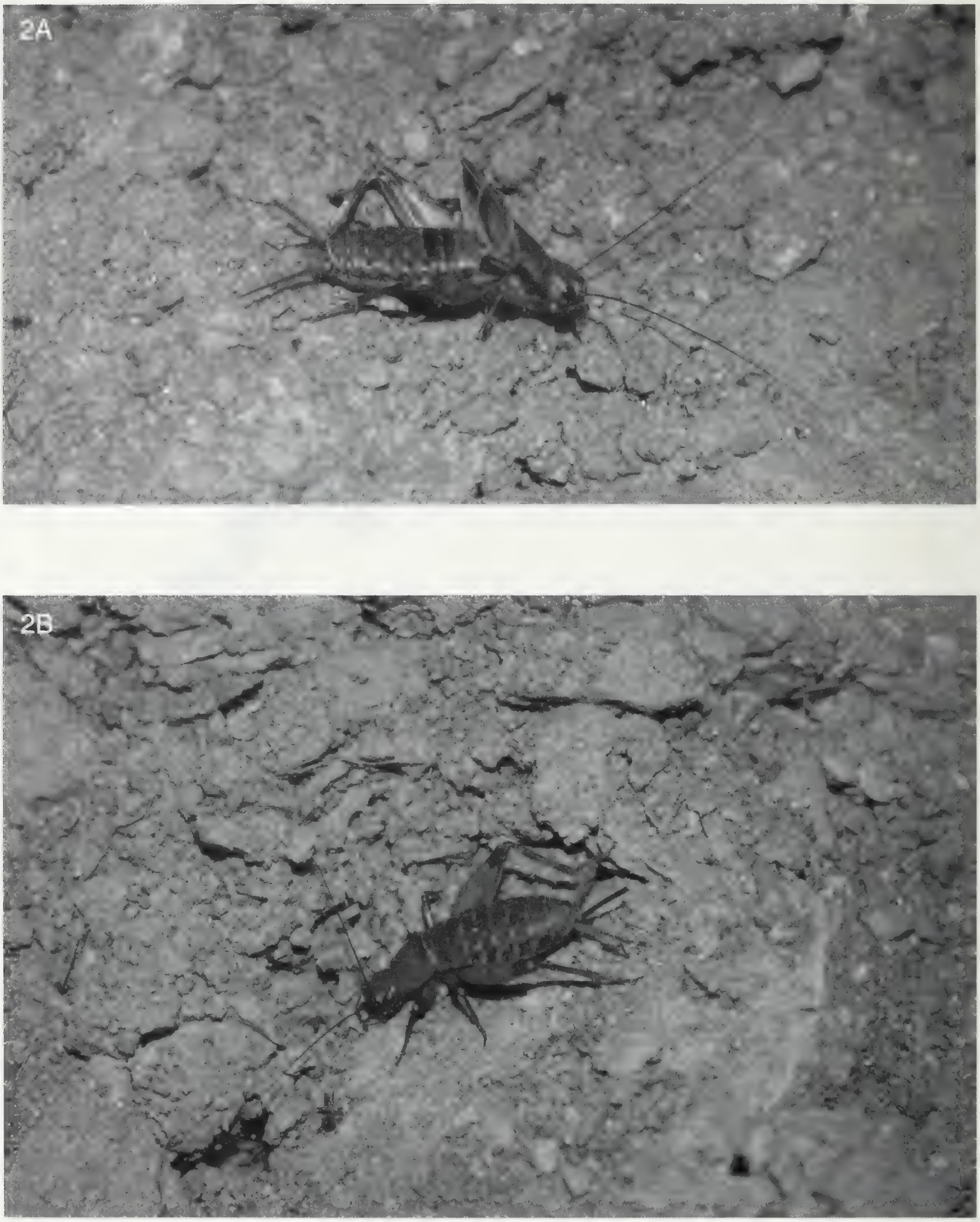

Fig. 2. *Hoplosphyrum boreale.* Fig 1A calling male; Fig 1B female (photos D. A. Gray).

ably searching for food and/or mates. Peak abundance was in early to mid October. Few individuals were observed in September, but by October 2, 2001 density had increased and was informally estimated at 1 to 2 individuals per square meter in suitable habitat. This further increased to an estimated 2 to 3 per square meter by 19 October, 2001. Abundance had markedly decreased by November 17, 2001 and by January 11, 2002 only two males were heard calling. At peak abundance in early October it was common to find several males within 10 cen-

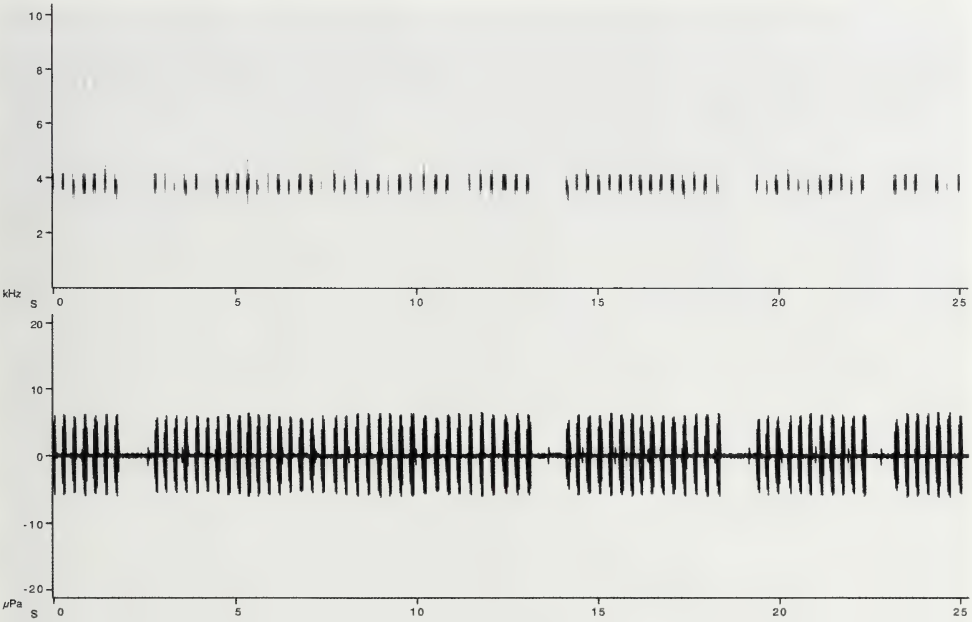

Fig. 3. Overview of calling song of *H. boreale* recorded in the field at 12.9 °C (25 seconds). Song consists of a series of chirps, each chirp composed of 3 pulses. The top panel shows frequency versus time; the bottom panel shows amplitude versus time. Amplitude values are not calibrated.

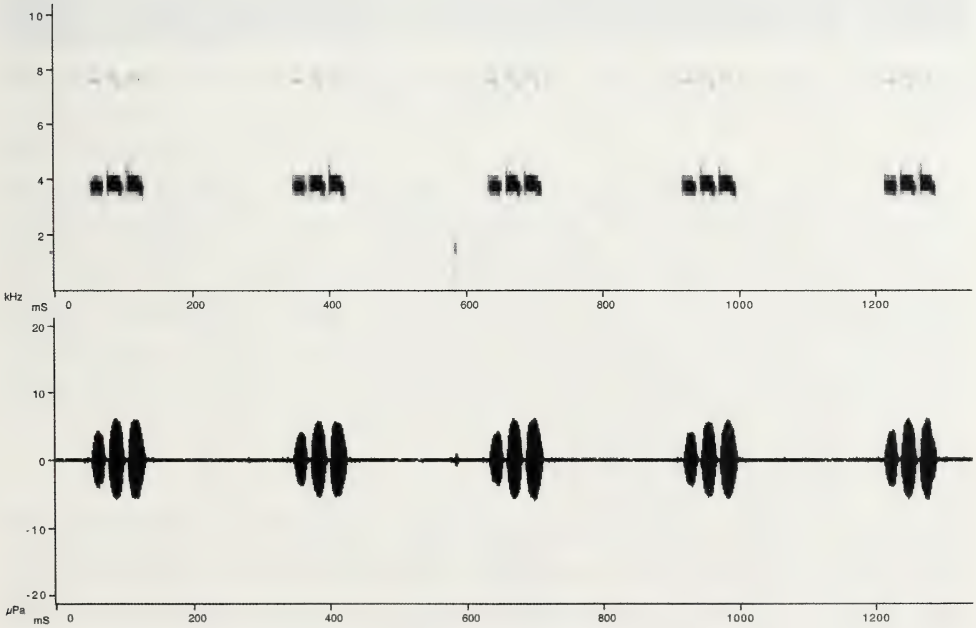

Fig. 4. Close-up of chirp structure in *H. boreale* recorded in the field at 12.9 °C (ca. 1.3 seconds). The top panel shows frequency versus time; the bottom panel shows amplitude versus time. Amplitude values are not calibrated.

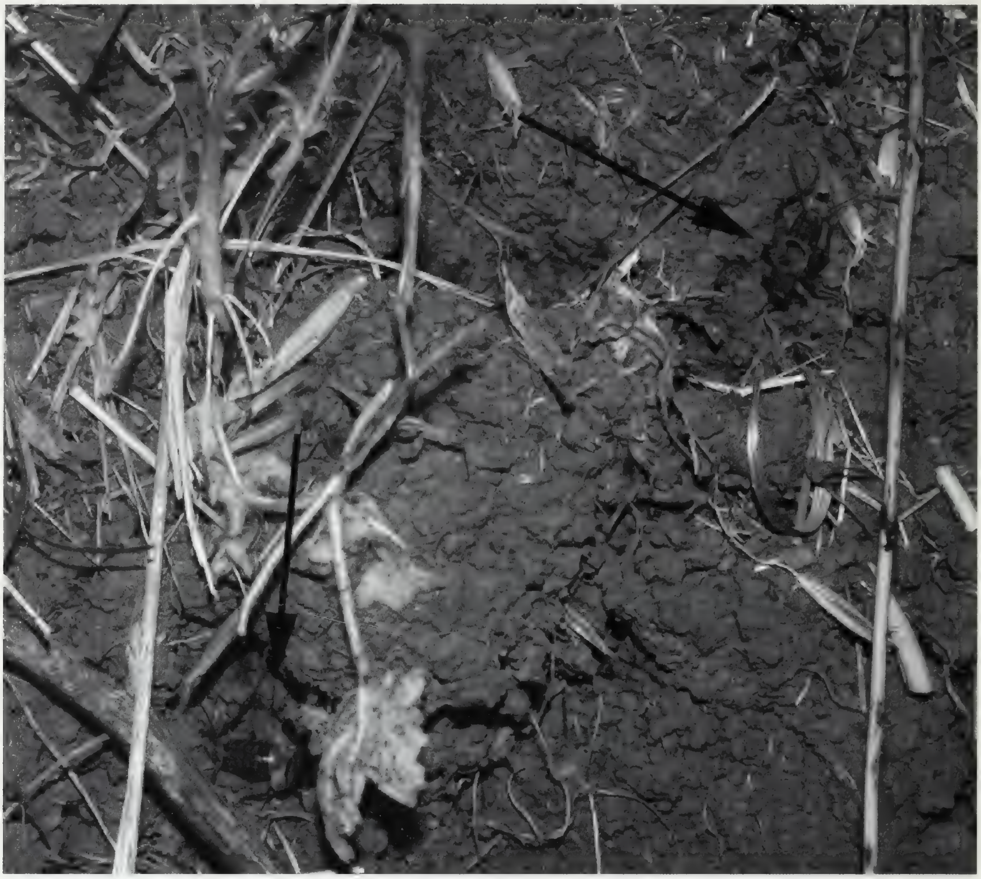

Fig. 5. Two males in close proximity without apparent aggression (photo D. A. Gray). Dark arrows indicate the positions of the two males, one of which is calling.

timeters of each other. A similar pattern of peak abundance in mid-fall was observed in 2002. Although not conclusive, these observations suggest a single generation per year. If the *H. boreale* life cycle is generally similar to that of other crickets, this would suggest the likelihood of an egg diapause during the winter months (Masaki & Walker 1987; Alexander 1968; McIntyre 1978; Tanaka et al. 1999). Consistent with this idea, we have had success at rearing *H. boreale* in the laboratory by imposing a 4 °C diapause for 60 days (Rakshpal 1962); direct hatching of eggs at room temperatures has been unsuccessful (D. A. Gray & J. Saidy, unpublished observations).

Field Mating Behavior.

Males were observed to call from cracks in the soil, while walking over relatively bare surfaces, frequently from under dried leaves, and infrequently while perched on vegetation. Males thus appear to adopt an active search strategy of mate finding in addition to site-tenacious calling. On numerous occasions males were observed to encounter other males while walking on the surface (Fig. 5). Obvious overt male-male aggression typical of field crickets (Alexander 1961; Hack 1997; Tachon et al. 1999) was never observed in the field however. Males appeared tolerant of the presence of other males within very close proximity. On one occasion, 2 males were observed with 1 female under a single fallen leaf.

Only one mating interacton was observed in the field. A male and female were encountered positioned approximately 8 cm from each other. The male was facing the female and producing song. The song sounded similar in structure to the calling song males sing when alone, and so prompted further study described below. After approximately 20 seconds, the female approached the male, he turned to face the other direction, and the female mounted the male immediately. The female remained on top of the male for 1–2 seconds, and then dismounted and walked away. No nuptial feeding was observed. Unfortunately the observation conditions made it impossible to determine if a spermatophore had been transferred to the female.

In order to quantify song and determine if different songs are used for calling (long-range mate attraction) and courtship (close-range mating interactions), as is commonly the case in field crickets (Alexander 1961; Fitzpatrick & Gray 2001; Walker & Masaki 1989), we recorded a sample of males in the laboratory twice each: once when the male was alone and had been held individually isolated for a minimum period of one week, and once when paired with a female. Males and females were wild caught and thus had unknown mating histories. Males and females were held individually as described above, but for recording purposes the lids of the male containers were replaced with mesh screen lids.

Calling males were recorded using a digital tape recorder (TASCAM DA-P1, 20 Hz − 20 kHz ± 1 dB, all reported dB re: 20 μPa, TASCAM America, Montebello, CA) set at mono, 48kHz 16-bit sampling, fitted with a Sennheiser MKE 2-P-C microphone (20 Hz − 20 kHz ± 3 dB, Sennheiser Electronic Corporation, Old Lyme, CT). The microphone was positioned 10 cm above the cricket to be recorded. We noted the temperature of each recording to the nearest 0.1 °C. Songs were transferred to a personal computer for analysis using CoolEdit 2000 (Syntrillium Software, Scottsdale, AZ). Laboratory recordings were made at temperatures ranging from 21.2 to 26.1 °C (Mean ± SD = 23.5 ± 1.3). We recorded a sample of 10 males two times each: once when the male was alone, and once after the introduction of a female; we additionally recorded calling song for another 5 male *H. boreale* and for 7 males of the currently undescribed species (Fig. 6). Song variables analyzed were the number of chirps per series (chirps/series), the time from the end of one series to the start of the next (inter-series interval), the duration of a chirp (chirp duration), the time from the end of one chirp to the start of the next within a series (inter-chirp interval), the number of chirps per second (chirp rate, calculated as 1/the chirp period, which equals the chirp duration plus the inter-chirp interval), the number of pulses per chirp (pulses/chirp), the duration of a single pulse (pulse duration), the number of pulses per second within a chirp (pulse rate, calculated as 1/the pulse period, where the pulse period equals the time from the start of one pulse within a chirp to the start of the next pulse within the same chirp), and the peak frequency of the chirp (frequency). Song data were adjusted to a common temperature of 20 °C by regression of song data on recording temperature, and then calculating the temperature adjusted data as $Song_{adj}$ = Song − (recording temp − 20)*slope of song on temperature for each song feature (Gray & Cade 1999, 2000; Martin et al. 2000).

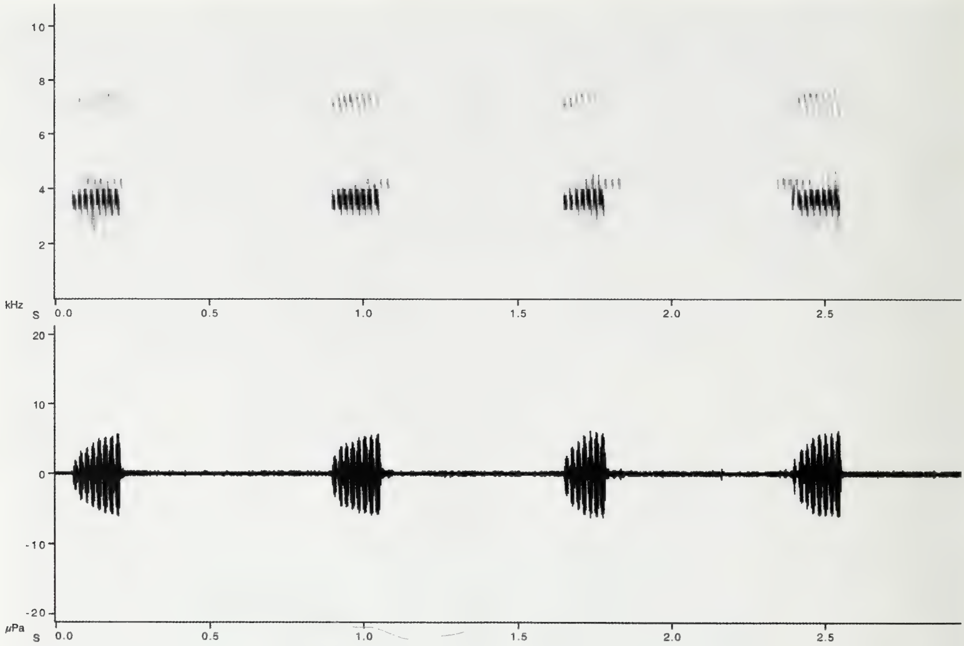

Fig. 6. Song of an unnamed species of *Hoplosphyrum* recorded in the field at 15 °C (ca. 3 seconds). The top panel shows frequency versus time; the bottom panel shows amplitude versus time. Amplitude values are not calibrated.

Several minutes of song were analyzed for each male (an average of 10 ± 7 chirp series for *H. boreale*).

The number of chirps per series appears to be the only song character notably different in calling and courtship song situations in *H. boreale* (Table 1). Song produced during courtship interactions has approximately one-half as many chirps per series as are produced when the male is calling alone. Statistical analysis confirms this impression (Z test of the difference between paired observations, $N = 10$ males, $P < 0.005$). Song produced in calling and courtship interactions did not differ in the inter-series interval, pulses per chirp, pulse duration, or chirp rate (all $P > 0.05$). Statistically significant differences were found in the inter-chirp interval, peak frequency, pulse rate, and the chirp duration (all $P < 0.05$), however given the magnitude of the differences which are small compared to the large difference in chirps per series, we question the biological significance of these differences.

The songs of the two species are likewise clearly distinct and non-overlapping (Table 1). The most distinctive features are the number of pulses/chirp ($F_{1,20} = 528.5$, $P < 0.0001$), and therefore chirp duration ($F_{1,20} = 400.6$, $P < 0.0001$), the inter-chirp interval ($F_{1,20} = 161.1$, $P < 0.0001$), and the chirp rate ($F_{1,20} = 610.9$, $P < 0.0001$), although other song features are also statistically significantly different (e.g., pulse duration, $F_{1,20} = 22.4$, $P < 0.0001$ and peak frequency $F_{1,20} = 124.2$, $P < 0.0001$). Pulse rate was the only song feature not to differ between species ($F_{1,20} = 0.0$, $P \gg 0.05$).

Table 1. Song data corrected to 20°C. Means ± SD's are given for each song character for *Hoplosphyrum boreale* calling and courtship songs, and for the calling song of an undescribed *Hoplosphyrum* species.

Species	Song	Chirps/ series	Inter-series interval (ms)	Pulses/ chirp	Inter-chirp interval (ms)	Pulse duration (ms)	Frequency (kHz)	Pulse rate	Chirp duration (ms)	Chirp rate
H. boreale	Call (*N* = 15)	18 ± 15	939 ± 460	2.7 ± 0.4	123 ± 17	12 ± 1	4.7 ± 0.2	49.6 ± 3.2	50 ± 7	5.7 ± 0.4
H. boreale	Court (*N* = 10)	8 ± 4	828 ± 416	2.7 ± 0.5	148 ± 32	13 ± 1	4.2 ± 0.2	56.7 ± 3.2	44 ± 8	5.4 ± 1.2
H. n.sp.	Call (*N* = 7)	*	*	7.4 ± 0.6	551 ± 132	15 ± 1	4.0 ± 0.1	49.6 ± 3.7	153 ± 18	1.4 ± 0.3

* Note: chirps are not arranged in series in the undescribed species, rather chirps follow a regular uninterrupted pattern.

Discussion

Our observations quantify song properties used in communication, and suggest avenues for future field and laboratory work. From our observations of field behavior at high density, it appears likely that males adopt a mixed mate search strategy of actively calling for females, actively searching for females, and potentially acting as satellites of other calling males. The payoff for actively searching for mates in crickets increases in high-density situations as observed in other species of crickets (Cade 1979; Cade & Cade 1992; Hissmann 1990).

While our data add to the published knowledge of scaly cricket biology and acoustic communication, they highlight the need for future work with these and related crickets. Although the taxonomy of the group has recently been revised for eastern North America, additional distributional and taxonomic work on western species is likely (R. E. Love, personal communication 2002). Characterizing the interesting ecological, behavioral, and evolutionary questions could involve decades more work. Specifically it will be interesting to address intra-specific inter-sexual selection based on acoustic features, further characterize mating behavior, and examine behavioral and other forms of reproductive isolation between species where they are found in sympatry.

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References

Alexander, R. D. 1961. Aggressiveness, territoriality, and sexual behavior in field crickets (Orthoptera: Gryllidae). Behaviour, **17**, 130–223.

———-. 1968. Life cycle origins, speciation, and related phenomena in crickets. Q. Rev. Biol., **43**, 1–41.

Andrade, M. C. B. and Mason, A. C. 2000. Male condition, female choice, and extreme variation in repeated mating in a scaly cricket, *Ornebius aperta* (Orthoptera: Gryllidae: Mogoplistinae). J. Insect Behavior, **13**, 483–497.

Cade, W. H. 1979. The evolution of alternative male reproductive strategies in field crickets. In: *Sexual Selection and Reproductive Competition in Insects* (Ed. by Blum, M. S. and Blum, N. A.), pp. 343–380. New York: Academic Press.

——— and Cade, E. S. 1992. Male mating success, calling and searching behaviour at high and low densities in the field cricket, *Gryllus integer.* Animal Behaviour, **43**, 49–56.

Dambach, M. and Beck, U. 1990. Mating in the scaly cricket *Cycloptiloides canariensis* (Orthoptera: Gryllidae: Mogoplistinae). Ethology, **85**, 289–301.

——— and Gras, A. 1995. Bioacoustics of a miniature cricket, *Cycloptiloides canariensis* (Orthoptera: Gryllidae: Mogoplistinae). *J. Exp. Biol.,* **198**, 721–728.

Fitzpatrick, M., J. and Gray, D. A. 2001. Divergence between the courtship songs of *Gryllus texensis* and *G. rubens* (Orthoptera: Gryllidae). Ethology, **107**, 1075–1086.

Gray, D. A. and Cade, W. H. 1999. Quantitative genetics of sexual selection in the field cricket, *Gryllus integer.* Evolution, **53**, 848–854.

———. 2000. Sexual selection and speciation in field crickets. Proc. Nat. Acad. of Sci., **97**, 14449–14454.

Hack, M. A. 1997. The energetic costs of fighting in the house cricket, *Acheta domesticus* (L.). Behavioral Ecology, **8**, 28–36.

Hissmann, K. 1990. Strategies of mate finding in the European field cricket (*Gryllus campestris*) at different population densities: a field study. Ecological Entomology, **15**, 281–291.

Love, R. E. and Walker, T. J. 1979. Systematics and acoustic behavior of scaly crickets (Orthoptera: Gryllidae: Mogoplistinae) of eastern United States. Trans. Amer. Entomological Soc., **105**, 1–66.

Martin, S. D., Gray, D. A. and Cade, W. H. 2000. Fine-scale temperature effects on cricket calling song. Can. J. Zool., **78**, 706–712.

Masaki, S. and Walker, T. J. 1987. Cricket life cycles. Evolutionary Biology, **21**, 349–423.

McIntyre, M. E. 1978. Some aspects of diapause in the field crickets *Pteronemobius nigrovus* and *P. bigelowi* (Orthoptera: Nemobiinae) with notes on their ecology. Mauri Ora, **6**, 3–10.

Otte, D., Eades, D. C. and Naskrecki, P. 2002. Orthoptera Species File Online (Version 2). http://OSF2.orthoptera.org/basic/HomePage.asp.

Rakshpal, R. 1962. Diapause in the eggs of *Gryllus pennsylvanicus* Burmeister (Orthoptera: Gryllidae). Can. J. Zool., **40**, 179–194.

Tachon, G., Murray, A. M., Gray, D. A. and Cade, W. H. 1999. Agonistic Displays and the Benefits of Fighting in the Field Cricket, *Gryllus bimaculatus*. J. Insect Behavior, **12**, 533–544.

Tanaka, S., Arai, T. and Tanaka, K. 1999. Nymphal development, diapause and cold-hardiness in a nymph-overwintering cricket. Entomological Science, **2**, 173–182.

Walker, T. J. and Masaki, S. 1989. Natural history. In: *Cricket Behavior and Neurobiology* (Ed. by Huber, F., Moore, T. E. and Loher, W.), pp. 1–42. Ithaca, N. Y.: Cornell University Press.

——— and Moore, T. E. 2002. Singing Insects of North America. http://buzz.ifas.ufl.edu/.

Yang, J.-T. and Yen, F.-S. 2001. Morphology and character evaluation of scales in scaly crickets (Orthoptera: Grylloidea: Mogoplistidae). Zoological Studies, **40**, 247–253.

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RESEARCH NOTES

Muskrats and Sage Pondweed in Valle de Mexicali: Opportunistic Feeding on a Spontaneous Resource

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Muskrats (*Ondatra zibethicus*) inhabit irrigation canals and agricultural drains in the Valle de Mexicali, Mexico (adjacent to the Imperial Valley, California) (Mellink 1995). Although local food sources have not been investigated, they are likely to consist mostly of stems, roots and seeds of aquatic plants, as they are elsewhere (Bellrose 1950; Dixon 1922; Hoffmeister 1986; Leopold 1959; Perry 1982). On 13 and 14 June 2002, we made some noteworthy observations in Canal Reforma.

This 15-m wide canal is one of two main canals used for the distribution of irrigation water throughout the Valle de Mexicali. Its banks were lined with reed (*Phragmites communis*), which due to recent dredging operations and clearing of vegetation was sparse and short. To our knowledge, the submerged aquatic plants in Canal Reforma have not been inventoried, but they include sage pondweed (*Stuckenia pectinata*) and Hydrilla (*Hydrilla verticillata*).

In a section of this canal (32°25.831′ Lat N, 115°18.352′ Long W), we found muskrats frantically feeding on sage pondweed. This species is an important wildlife food wherever it occurs. The tubers, stems, leaves and seeds are consumed by many species, especially waterbirds (Martin et al. 1951). Having leaves and seedheads with 10.2–17.1% and 9.6–12.2% protein, respectively, on a dry weight basis (Anderson and Low 1976; Linn et al. 1975), it is a high-quality forage (De Alba 1971). A sample of floating sage pondweed from the Canal Reforma collected by us contained 12.44% crude protein and rendered 3,509 cal/g (analysis performed at the Escuela de Medicina Veterinaria, Universidad Autónoma de Baja California). Sage pondweed has been observed as food for muskrats before (Hoffmeister 1986; Martin et al. 1951; McAtee 1911), but the feeding behavior we recorded seems unusual.

As a result of chain-dredging operations upstream in the canal, there were abundant clumps of sage pondweed drifting with the current (up to 1 m in diameter). Individual muskrats swam toward one such clump and, positioning themselves on it, they avidly and continually fed on the sage pondweed, apparently without using their forepaws. Most of the time, the muskrats held their tails upwards and out of the water. During the feeding they drifted several hundred meters, sometimes reaching the next water control structure, at which point they returned swimming against the current. The water current (estimated by following drifting clumps along a step-measured section and timed with a wristwatch) was about 30 m min-1. Between about 19:00 and 19:30 h, on 13 June, there were 10 muskrats feeding in this manner. Between 08:15 and 09:20 h the following morning, 16 muskrats engaged in this type of feeding. Earlier we had seen, but not counted, several other individuals exhibiting the same behavior. Water temperature on 14 June was 27.2°C, and the flow seemed somewhat slower than the afternoon before.

The morning of 14 June, we witnessed two other feeding behaviors by muskrats on sage pondweed. The first was by an individual standing in the water feeding on a clump that had been trapped on the side of the canal. The other was by a muskrat which gathered a clump of sage from the middle of the canal, pushed it to an exposed area on the side, and fed there. This was a large muskrat, that appeared to have an inflammated vulva and protruding nipples, and we surmised it was a female close to parturition. While feeding, she would hold a bundle of sage pondweed with her forepaws and bite through it producing many cuttings a few centimeters long. After depositing the bundle on the ground, she ate the clippings individually, picking them up with her forepaws. When she finished consuming the first clump, she entered the canal, let several clumps drift by and proceeded to haul another one to shore. Although the forage she actively selected appeared greener than most of what was drifting in the canal, it contained only slightly more protein (12.69% vs. 12.44%). This individual was joined by another, and after exhibiting greeting behavior in the form of nose to face contact, the later one groomed the female for several seconds and began feeding from the same pile of food. Eventually the female departed abruptly, and the second muskrat continued to eat the remaining forage.

Muskrats usually feed at night (Perry 1982), but we found many individuals actively feeding during daylight. Around 16:45, on 13 June, several muskrats were moving in the canal, although we did not carry out detailed observations. The following morning several muskrats were still actively feeding in the middle of the canal at 09:20. Thus, the muskrats were feeding in bright sunlight more than 3 hours before sunset (19:55) and almost 4 hours after sunrise (05:38). Also, muskrats are believed to be rather “shy,” eating their food in areas with protective cover or in feeding dens (Hoffmeister 1986; Perry 1982). At Canal Reforma, they were not only very active during broad daylight, but also quite bold, drifting and feeding in the middle of the canal.

During the months before and after these observations one of us (EM; 15 April, 30 April, 5 June, 24 July, 26 July) drove repeatedly along this same canal and noted only an occasional muskrat and much fewer floating patches of aquatic vegetation. No feeding on sage pondweed was observed. Close to dusk on 22 May 2003, EM recorded one muskrat riding a clump of vegetation that appeared to be decaying, and was feeding selectively on it, possibly on seeds. The clump looked similar to the pondweed clumps but we did not identify the plants composing it. Several other muskrats were swimming across the canal, and we did not observe any other floating clumps of vegetation.

Hence, muskrat feeding behavior seems versatile enough to allow them to take advantage of an unusual nutritional opportunity. The eagerness of the muskrats for feeding on sage pondweed was probably a result of both its high availability, resulting from dredging the canal upstream, and by its relatively high nutritive value. Our observations also suggest that the danger of being much more exposed while drifting in the center of the canal and during broad daylight is offset by the abundant supply of a high quality food.

Acknowledgments

Jose Delgadillo kindly verified our identification of sage pondweed and reed. Alejandra López-Soto and Dixie May performed the chemical analysis of our very small samples. Sharon Herzka provided very important editorial assistance. Our deepest appreciation to all them. Observations were made while carrying out field work for a UCMexus-sponsored project.

Literature Cited

Anderson, M. G., and J. B. Low. 1976. Use of sago pondweed by waterfowl on Delta Marsh, Manitoba. J. Wildlife Management 40:233–242.

Bellrose, F.C. 1950. The relationship of muskrat populations to various marsh and aquatic plants. J. Wildlife Management 14:299–315.

De Alba, J. 1971. Alimentación del ganado en América Latina. 2nd ed. Prensa Médica Mexicana. México, D.F. 475 pp.

Dixon, J. 1922. Rodents and reclamation in the Imperial Valley. J. Mammalogy 3:136–146.

Hoffmeister, D.F. 1986. The mammals of Arizona. University of Arizona Press. Tucson, Ariz. 602 pp.

Leopold, A.S. 1959. Wildlife of Mexico. University of California. Berkeley. 568 pp.

Linn, J.G., R.D. Goddrich, D.E. Otterby, J.C. Meiske and E.J. Staba. 1975. Nutritive value of dried or ensiled aquatic plants. II. Digestibility by sheep. J. Anim. Sci. 41:610–615.

Martin, A.C., H.S. Zim and A.L. Nelson. 1951. American wildlife & plants; a guide to wildlife food habits. Dover. New York. 500 pp.

McAtee, W. L. 1911. Three important wild-duck foods. U.S. Bureau of Biological Surveys Circular 81. 19 pp.

Mellink, E. 1995. Status of the muskrat in the Valle de Mexicali and Delta del Rio Colorado, Mexico. Calif. Fish and Game 81:33–38.

Perry, H.R. 1982. Muskrats *Ondatra zibethicus* and *Neofiber alleni.* Pp. 282–325 in J.A. Chapman and G.A. Feldhamer (eds.). Wild mammals of North America; biology, management, and economics. Johns Hopkins University Press. Baltimore.

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Brattstrom, B. H. 1969. The Condor in California. Pp. 369–382 *in* Vertebrates of California. (S. E. Payne, ed.), Univ. California Press, xii + 635 pp.

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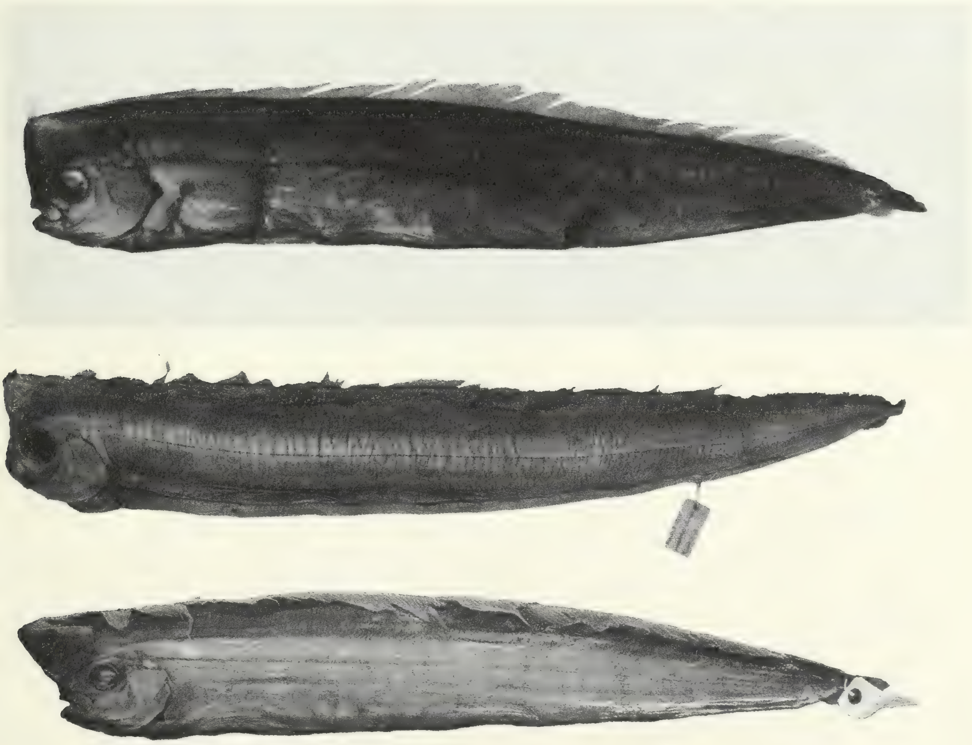

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Late Pleistocene Salamander (Caudata; Plethodontidae) from Santa Rosa Island, Northern Channel Islands, California

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Abstract.—We present the first record of a late Pleistocene salamander, *Batrachoseps* (Plethodontidae; Bolitoglossini) from the Northern Channel Islands. Fossils were recovered in sediments by using 700 μm mesh wet sieving. Ocean currents could have transported any or all of the known seven families of salamanders presently inhabiting coastal USA to the islands. We suggest that only the Plethodontini and Bolitoglossini were likely to successfully colonize the Pleistocene-age coalesced island, Santarosae, due to their lack of an aquatic larval stage. The recovery of *Batrachoseps* from Carrington Point implies a moist, organic understory, but it does not dictate a particular habitat reconstruction.

The Northern Channel Islands today are 21 km west of south-central California and include Anacapa, Santa Cruz, Santa Rosa, and San Miguel islands (Fig. 1). These islands receive much-deserved attention due to their archaeology, marine and insular biotic communities, and geologic setting (Browne et al. 2002). Their environments and archaeology are well understood for the present and recent past (late Holocene; most recent 5,000 years). What is not understood is the reconstruction of the islands during the most recent glacial regime of the Pleistocene (Wisconsinan Glaciation; dating approximately 11,000–80,000 years ago). Some of the more intriguing paleontological remains known from the islands include the late Pleistocene pygmy mammoth, *Mammuthus exilis* (Stock and Furlong 1928; Roth 1996; Agenbroad 1998a, b, 2002). Equally as interesting are the recovery of small mammals and birds dating to the Holocene and late Pleistocene (Guthrie 1980, 1993, 1998; Guthrie et al. 2002). The composition of present reptile and amphibian faunas are fairly well understood (Savage 1967; Wilcox 1980; Bezy et al. 1980), yet only a few reptiles have been recorded as late Pleistocene inhabitants (San Miguel Island; Guthrie 1993). Until now, no fossil salamanders (Amphibia, Caudata) have been recovered from the various deposits on the Northern Channel Islands (Johnson 1978; D. Guthrie, pers. comm. September 2002). Here we report salamander and other vertebrate remains from Carrington Point, Santa Rosa Island.

Fossils from Carrington Point, Santa Rosa Island

Methods

Santa Rosa Island was extensively surveyed for localities containing mammoth (Agenbroad 1998b, 2002), and during that process, a microvertebrate locality was

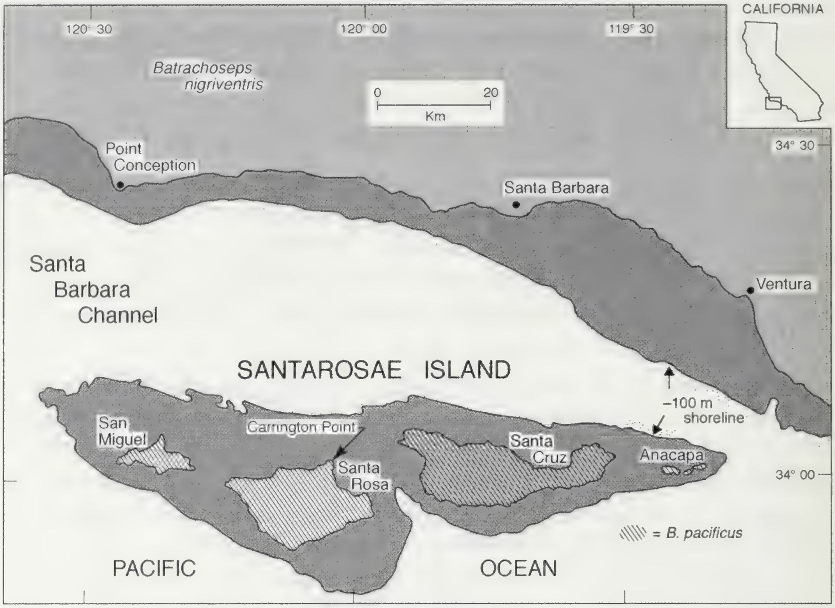
120° 30
120° 00
119° 30
CALIFORNIA
Batrachoseps nigriventris
0 20
Km
Point Conception
Santa Barbara
34° 30
Ventura
Santa Barbara Channel
SANTAROSAE ISLAND
–100 m shoreline
San Miguel
Carrington Point
Santa Rosa
Santa Cruz
Anacapa
34° 00
= B. pacificus
PACIFIC
OCEAN

Fig. 1. Map of the Northern Channel Islands and coastal California illustrating the relative positions between the four major islands and the mainland. The 100 m isobath shoreline shows that the islands coalesced into one large island called Santarosae and that the mainland coast extended further into the Santa Barbara Channel during glacial sea level lowering (adapted from Johnson [1978]). Carrington Point is located on the north end of Santa Rosa Island. Modern distribution of *Batrachoseps pacificus* is on all four of the islands (Slevin [1928] and Wake [1996] state that the species is not on Anacapa Islands). *B. nigriventris* is found today on the mainland and on Santa Cruz Island.

discovered (similar to the survey described by Guthrie (1993) for San Miguel Island). Wet sieving sediments from the microvertebrate locality through 700 μm mesh is yielding fossils typically not recovered on Santa Rosa Island.

Associated Fauna

Three gallon-size bags of sediments removed from deposits laterally-adjacent to the mammoth locality at Carrington Point (Fig. 1; Agenbroad 1998a) yielded fish skeletal remains (Channel Islands National Park specimen number; CHIS 6836, 6844, 6847), *Microtus* sp. (CHIS 6838), a small bird (CHIS 6847), and four salamander vertebrae (CHIS 6840–6843). *Microtus* does not live today on Santa Rosa Island (Wenner and Johnson 1980). We could not determine if the fragmented molar of *Microtus* from Carrington Point represents the extinct *M. miguelensis* (Guthrie 1998) or some other extant taxon from the mainland; however, CHIS 6838 represents the first fossil record of this taxon on Santa Rosa.

Taphonomy

The taphonomic history for this microfauna is not fully understood. The locality is an open-air site today and is rapidly eroding into the sea. Most of the bones exhibit breakage, with little-to-no dissolution. Owls, gulls, ravens, condor, and hawks, among other birds, will prey or scavenge on small vertebrates and produce stomach pellets of bones. These birds are known from sub-fossil and fossil contexts on the islands (Guthrie 1980; Guthrie et al. 2002). Mammalian carnivores, such as the insular gray fox (*Urocyon littoralis*) and spotted skunk (*Spilogale gracilis*), are also known from the islands and are documented to prey on small vertebrates (Crooks and Van Vuren 1994). These predators and scavengers could easily account for the broken microfaunal skeletal remains recovered from Carrington Point. The distance of the islands from the mainland supports the concept of a local and insular origin for the fauna.

Chronology

Bone collagen from the nearby mammoth skeleton produced an AMS radiocarbon age of 12,840±140 years before present (CAMS 24429; Agenbroad 1998b). Because the microfossils exhibit the typically bleached-white, mottled with black appearance found on many of the *Mammuthus* bones and the close horizontal and vertical proximity between the two localities, we consider the microfaunal remains to be temporally associated with the mammoth, and not a younger intrusive. We propose that the mammoth remains and the salamander vertebrae reported here date to the late Pleistocene (late Wisconsinan Glaciation) and chronologically are part of the Rancholabrean North American Land Mammal Age.

Salamander Specimens

One salamander vertebra is caudal (CHIS 6843), with the remaining three representing mid-trunk. Two of these are fragmented, yet are identical in morphology to the near-complete specimen (CHIS 6840). These vertebrae preserve enough traits to permit generic identification (Fig. 2). Comparative osteology used here follows Wake (1963, 1966). Our analysis includes an examination of select characters found, or not found, on vertebrae of western North American salamanders within the families mentioned below; however, a detailed and comprehensive trait analysis resulting in a complete phylogenetic assessment is not within the scope of this project.

Description

Table 1 presents the measurements taken from the three trunk vertebrae. Traits denoted with an '*' indicate characters used as autapomorphies for *Batrachoseps* (see below). Centrum ratios (*) range from 2.80–3.25 on the fossils, which are similar to those of extant *Plethodon, Hydromantes,* and *Batrachoseps. Ensatina* has a relatively stout centrum, with a ratio about 2.50, and those of extant *Aneides* range from 1.80 to 2.40 (Wake 1966). No basapophysis (*) is present on the fossils or on vertebrae of extant *Batrachoseps, Hydromantes,* or *Ensatina*; basapophyseal processes are faintly indicated in *Aneides* and slightly developed on some species of *Plethodon* (Wake 1963). No alar expansion (*) is present on the fossils, or on extant *Batrachoseps* and *Hydromantes* (as it is on some species of *Aneides*). The transverse process on CHIS 6840 exceeds the zygopophyseal margins (Fig. 2B) and arise united, but immediately separates (generating the diapophysis and parapophysis)—a character observed on extant *Batrachoseps* (*). The parapophyses are slightly anterior of the diapophyses (*; Fig. 2Cb), and a neural ridge (spine) is weakly developed on the fossils. The diapophyses and the parapophyses project sharply posterolaterally (at approximately 45°, Fig. 2B; *) on CHIS 6840 and *Batrachoseps*; this orientation is not observed in *Plethodon,*

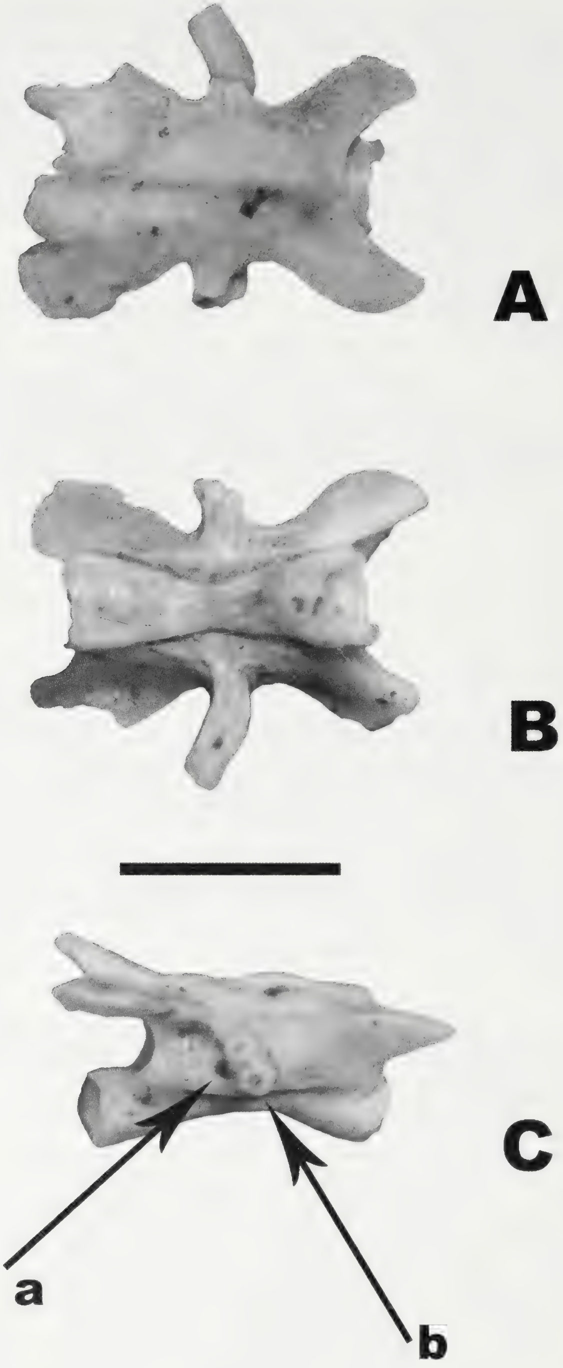

Fig. 2. Photograph of late Pleistocene *Batrachoseps* vertebra from Carrington Point, Santa Rosa Island. A, CHIS 6840 in dorsal view; B, ventral view; and C, lateral view. On C the spinal nerve foreman is located at 'a' and the offset diapophysis (dorsal, top) and parapophysis (ventral) are located at 'b.' Anterior to the right. Scale bar equals 1 mm.

Table 1. Measurements of *Batrachoseps* trunk vertebra from Carrington Point, Santa Rosa Island. Measurements (mm) and terminology follow Wake (1963, 1966). CL, centrum length; CR, centrum ratio: CL/PCD; PCD, post-centural diameter; PO, postzygapophysis; PR, prezygapophysis.

CHIS Specimen	PCD	CL	CR	PR–PR	PR–PO
6840	0.50	1.40	2.80	1.30	2.05
6841	0.40	1.30	3.25	1.10	—
6842	0.70	2.00	2.85	—	—

Ensatina, Aneides, or *Hydromantes* (Tihen and Wake 1981; Clark 1985). No hypophysis is present on the fossils. A divided hyperapophysis is present and moderately developed on the fossils, as on all extant plethodontids.

The spinal nerve pattern observed on the fossils (Fig. 2Ca) is similar to those found on plethodontids and ambystomatids. The patterns on these taxa differ from those on other salamanders (Edwards 1976). Characters of the diapophyses and parapophyses (presented above) and the overall size of the vertebrae omit the fossils from the Rhyacotritonidae, Ambystomatidae, Dicamptodontidae, and Salamandridae. The combination of traits displayed by CHIS 6840 and 6841 (and partly by CHIS 6842; presented above) appear to be autapomorphies for *Batrachoseps* (*), and do not occur on other plethodontid species; the three trunk vertebrae represent *Batrachoseps.* Characters found on the vertebrae are not species specific.

Discussion

Recent-West Coast Salamanders

Members of the following families of salamanders live today along the western North American coast and coastal lowlands up into the mountains, areas receiving significant amounts of rainfall: Ambystomatidae, Dicamptodontidae, Plethodontidae, Rhyacotritonidae, Salamandridae (Petranka 1998). Although salamander species are often common to abundant in coastal habitats, especially those within Plethodontidae, few are known on the coastal islands. Plethodontidae (lungless salamanders) is the largest family of salamanders, containing 27 genera in two subfamilies (Desmognathinae and Plethodontinae; Dunn 1926; Petranka 1998). Of the three tribes within the Plethodontinae, two occur predominantly along the western portions of continental USA. In this region the Plethodontini include *Aneides* (climbing salamanders), *Ensatina* (ensatina), and *Plethodon* (woodland salamanders); and the Bolitoglossini include *Batrachoseps* (slender salamanders) and *Hydromantes* (web-toed salamanders) (Wake 1993; Jackman et al. 1997). The only salamanders known to inhabit the Channel Islands today are one species of *Aneides* and two species of *Batrachoseps* (Savage 1967; Petranka 1998).

Batrachoseps is monophyletic and shares with all members of the Plethodontidae many morphological synapomorphies (see Jackman et al. 1997; Jockusch et al. 2002). Possibly twenty species of *Batrachoseps* are found today from northern Baja California, California, and Oregon, of which only a few are of direct significance to our study (Fig. 1; see discussions and details in Jockusch et al. 1998; Petranka 1998; Wake and Jockusch 2000; Jockusch and Wake 2002; Grismer 2002; Stebbins 2003).

All species of *Batrachoseps* are morphologically and ecologically specialized for subterranean life. Activity on the surface is limited to periods of favorable temperature and moisture conditions, predominantly during the rainy winter months. *Batrachoseps* cannot actively burrow so they rely on passages excavated by other animals or space produced by roots and soil shrinkage. This peculiar behavior permits the elongate salamander to occupy habitats ranging from moist coastal and montane areas to oak and pine savannas, grasslands, and rarely desert springs and seeps (Slevin 1928; Yanev 1980; Wake 1996).

Fossil-West Coast Salamanders

The fossil record of salamanders from deposits west of the Sierra Nevada appears scant in comparison to their common occurrence in the region today. Salamanders likely occur in a variety of fossil deposits, however, collecting biases by researchers may have omitted them from most collections due to their extremely small size. *Aneides lugubris* (arboreal salamander) is known from the late Pleistocene of Newport Beach Mesa, coastal California (Hudson and Brattstrom 1977). Vertebrae of *Hydromantes* are identified from a late Pleistocene packrat midden deposit in a cave in Kings Canyon, California (Mead et al. 1985). Foot prints of *Batrachoseps* are reported from the late Miocene from near Columbia, California (Peabody 1959; Estes 1981). Clark (1985) records *Aneides lugubris* and *Batrachoseps* from the latest Miocene of the San Francisco Bay area, California. Plethodontids, ambystomatids, and salamandrids of Holocene and late Pleistocene age are being recovered from sediments in Oregon Caves, Oregon (Mead et al. 2000).

Islands, Sea Level Changes, and Herpetofaunas

The four individual islands of the Northern Channel Islands today have surface areas of 2.9 km^2 (Anacapa), 249 km^2 (Santa Cruz), 217 km^2 (Santa Rosa), and 37 km^2 (San Miguel; Philbrick 1967). Glacial eustatic sea level low stands during the late Pleistocene merged the islands into a larger land mass called Santarosae (Orr 1968; Fig. 1), which had a calculated surface area of 2,046 km^2 (based on the 100m-isobath; Johnson 1978). Eustatic sea levels have changed dramatically during and since the late Pleistocene (Fairbridge 1961). Approximately 20,000 years ago Santarosae was at an all-time high surface area (Johnson 1978; Agenbroad 1998a) and has since been diminishing in size.

Johnson (1978), Junger and Johnson (1980), Vedder and Howell (1980), Wenner and Johnson (1980) illustrated that there was no land bridge from Santarosae to the mainland at anytime during the Pleistocene, although the mainland was within 6 to 10 km (Fig. 1). Savage (1967) stated that the present day herpetofauna of the Northern Channel Islands is depauperate and includes a unique assemblage of wide-ranging forms from the nearby mainland, including: 3 species of salamanders, 1 anuran, 13 lizards, and 11 snakes, for a total of 28 taxa. It is stated that these species arrived via over-water dispersal during the Pleistocene (Savage 1967; Wenner and Johnson 1980). The currently-known fossil record of the insular herpetofauna has only one species of snake, one lizard (Guthrie 1993, 1998), and, now, one salamander. Clearly the Pleistocene herpetofauna is not fully realized, nor is the chronology or mode of transport to the islands.

The two largest islands today (Santa Cruz and Santa Rosa) have steep mountainous ridges, hilly uplands, and major valleys oriented east-west. The present prevailing winds come from the northwest, with some paralleling the coastal current entering the area of the Northern Channel Islands from the north (Johnson 1977). The Northern Channel Islands have a predominately Mediterranean climate today, with mild wet winters and dry warm summers. Varied topography on the two islands permit ecological areas with significant microclimatic differences. Santa Cruz Island is unusual for the islands as it has a steep interior valley. Small springs and seeps that flow year-round are located over much of the larger islands, especially on the northern side of Santa Cruz (Junak et al. 1995).

We question which, if any, additional species of salamanders colonized the island during the Pleistocene. We also question whether the Northern Channel Islands of today or Santarosae of the Pleistocene could support additional species of salamanders other than plethodontids. Based on the present distribution of salamanders along the immediate mainland, we are not surprised that the Northern Channel Islands today are inhabited by *Batrachoseps* and *Aneides,* and would expect *Ensatina* to be found in the recent past.

Over-water transport could introduce other salamanders (ambystomatids, dicamptodontids, rhyacotritonids, salamandrids) from the mainland to Santarosae. However, the aquatic larval stages through which these salamanders develop perhaps preclude establishing a viable population on the Northern Channel Islands. For instance, *Dicamptodon* larvae require approximately two to four years in a stream to reach metamorphosis (Petranka 1998). In contrast, the Plethodontini and Bolitoglossini lack an aquatic larval stage (Petranka 1998) and possibly were more likely to successfully colonize Santarosae with its limited surface streams, yet humid maritime environment and climate.

Paleoenvironments

Little is known of the Northern Channel Islands to permit an accurate or detailed reconstruction of the environments during the Pleistocene—any fossil evidence is noteworthy. Recovering *Batrachoseps* at Carrington Point would suggest an environment of leaf litter understory, at least locally, although the genus lives in a wide variety of moist habitats (see Slevin 1928; Wake 1996). Macrofossils from Cañada de los Sauces, Santa Cruz Island, indicate a woodland of trees and shrubs (consisting of *Arctostaphylos, Ceanothus, Cornus, Cupressus, Myrica, Pinus,* and *Pseudotsuga*) dating to about 14,200 radiocarbon years ago (Chaney and Mason 1930; Johnson 1977). This habitat would have been ideal for salamanders.

Summary and Conclusions

Wet screen washing sediments through micromesh sieves of 700 μm mesh has permitted the first recovery of fossil salamanders from Santa Rosa Island of the Northern Channel Islands. These vertebrae are associated with other mammal remains including the skeleton of the extinct pygmy mammoth, all dating to approximately 12,840 years before present. Four vertebrae were identified as *Batrachoseps,* one of two taxa of salamanders living on the islands today; the species could not be determined. Clearly the fossils presented here demonstrate that additional micromesh sieving of sediments from a multitude of deposits will lead to the recovery of as yet unknown insular fossil species (possibly including the delicate cranial remains of salamanders that are diagnostic to species; Marlow et al. 1979) and therefore provide a more detailed reconstruction of the Pleistocene environments. The recovery of *Batrachoseps* from Carrington Point implies a moist, organic understory, but it does not dictate a particular habitat reconstruction. *Batrachoseps* is not known from the location today.

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Literature Cited

Agenbroad, L. D. 1998a. Pygmy (dwarf) mammoths of the Channel Islands of California. Mammoth Site of Hot Springs, South Dakota, Inc. 27 pp.

———. 1998b. New pygmy mammoth (*Mammuthus exilis*) localities and radiocarbon dates from San Miguel, Santa Rosa, and Santa Cruz Islands, California. Pp 169–175 *in* Contributions to the Geology of the Northern Channel Islands. (P. Weigand, ed.), So. Cal. Pacific Section Am. Ass. Pet. Geol., Bakersfield, Cal., 196 pp.

———. 2002. New localities, chronology, and comparisons for the pygmy mammoth (*Mammuthus exilis*): 1994–1998. Pp. 518–524 *in* Proceedings of the Fifth California Islands Symposium. (D. R. Browne, K. L. Mitchell, and H. W. Chaney, eds.), Santa Barbara Mus. Nat. Hist., Cal., 749 pp.

Bezy, R. L., G. C. Gorman, G. A. Adest, and Y. J. Kim. 1980. Divergence in the island night lizard *Xantusia riversiana* (Sauria: Xantusiidae). Pp. 565–583 *in* The California Islands: Proceedings of a Multidisciplinary Symposium. (D. M. Power, ed.), Santa Barbara Mus. Nat. Hist., Cal., 787 pp.

Browne, D. R., K. L. Mitchell, and H. W. Chaney (eds.). 2002. Proceedings of the Fifth California Islands Symposium. Santa Barbara Mus. Nat. Hist., Cal., 749 pp.

Chaney, R., and H. Mason. 1930. A Pleistocene flora from Santa Cruz Island, California. Carnegie Inst. Washington Publ. 415:1–24.

Clark, J. M. 1985. Fossil plethodontid salamanders from the latest Miocene of California. J. Herpetol., 19:41–47.

Crooks, K. R., and D. Van Vuren. 1994. Conservation of the island spotted skunk and island fox in recovering island ecosystem. Pp. 379–385 *in* The Fourth California Islands Symposium: Update on the Status of Resources. (W. L. Halvorson and G. J. Maender, eds.), Santa Barbara Mus. Nat. Hist., Cal., 530 pp.

Dunn, E. R. 1926 (1972). Salamanders of the family Plethodontidae. Smith College, Massachusetts, 446 pp.

Edwards, J. L. 1976. Spinal nerves and their bearing on salamander phylogeny. J. Morph., 148:305–327.

Estes, R. 1981. Encyclopedia of Paleoherpetology. Gymnophiona, Caudata. Vol. 2, Part 2:1–115.

Fairbridge, R. 1961. Eustatic changes in sea level. Pp. 99–185 *in* Physics and Chemistry of the Earth. Vol. 4. (L. H. Ahrens, F. Press, K. Rankama, and S. K. Runcorn, eds.), Pergammon Press, 317 pp.

Grismer, L. L. 2002. Amphibians and Reptiles of Baja California. Univ. Cal. Press, 399 pp.

Guthrie, D. A. 1980. Analysis of avifaunal and bat remains from midden sites on San Miguel Island. Pp. 689–702 *in* The California Islands: Proceedings of a Multidisciplinary Symposium. (D. M. Power, ed.), Santa Barbara Mus. Nat. Hist., Cal., 787 pp.

———. 1993. New information on the prehistoric fauna of San Miguel Island, California. Pp. 405–416 *in* Third California Islands Symposium: Recent Advances in Research on the California Islands. (F. G. Hochberg, ed.), Santa Barbara Mus. Nat. Hist., Cal.

———. 1998. Fossil vertebrates from Pleistocene terrestrial deposits on the Northern Channel Islands, southern California. Pp. 187–192 *in* Contributions to the Geology of the Northern Channel Islands. (P. Weigand, ed.), So. Cal. Pacific Section Am. Ass. Pet. Geol., Bakersfield, Cal., 196 pp.

———, H. W. Thomas, and G. L. Kennedy. 2002. A new species of extinct late Pleistocene puffin (Aves: Alcidae) from the southern California Channel Islands. Pp 525–530 *in* Proceedings of the Fifth California Islands Symposium. (D. R. Browne, K. L. Mitchell, and H. W. Chaney, eds.), Santa Barbara Mus. Nat. Hist., Cal., 749 pp.

Hudson, D. M., and B. H. Brattstrom. 1977. A small herpetofauna from the Late Pleistocene of Newport Beach Mesa, Orange County, California. Bull. So. Cal. Acad. Sci., 76:16–20.

Jackman, T. R., G. Applebaum, and D. B. Wake. 1997. Phylogenetic relationships of Bolitoglossine salamanders: a demonstration of the effects of combining morphological and molecular data sets. Mol. Biol. Evol., 14:883–891.

Jockusch, E L., D. B. Wake, and K. P. Yanev. 1998. New species of slender salmanders, *Batrachoseps* (Amphibia: Plethodontidae), from the Sierra Nevada of California. Los Angeles County Mus. Contr. Sci., 472:1–17.

———, and D. E. Wake. 2002. Falling apart and merging: diversification of slender salamanders (Plethodontidae: *Batrachoseps*) of the America West. Biol. J. Linnean Soc., 76:361–391.

———, K. P. Yanev, and D. B. Wake. 2002. Molecular phylogenetic analysis of slender salamanders, genus *Batrachoseps* (Amphibia: Plethodontidae), from central coastal California with descriptions of four new species. Herpt. Mono., 15:54–99.

Johnson, D. L. 1977. The late Quaternary climate of coastal California: evidence for an Ice Age refugium. Quat. Res., 8:154–179.

———. 1978. The origin of island mammoths and the Quaternary land bridge history of the Northern Channel Islands, California. Quat. Res., 10:204–225.

———. 1980. Problems in the land vertebrate zoogeography of certain islands and the swimming powers of elephants. J. Biogeogr., 7:383–398.

Junak, S., T. Ayers, R. Scott, D. Wilken, and D. Young. 1995. A flora of Santa Cruz Island. Santa Barbara Botanic Garden, Santa Barbara, 397 pp.

Junger, A., and D. L. Johnson. 1980. Was there a Quaternary land bridge to the Northern Channel Islands? Pp. 33–39 *in* The California Islands: Proceedings of a Multidisciplinary Symposium. (D. M. Power, ed.), Santa Barbara Mus. Nat. Hist., Cal., 787 pp.

Marlow, R. W., J. M. Brode, and D. B. Wake. 1979. A new salamander, genus *Batrachoseps,* from the Inyo Mountains of California, with a discussion of relationships in the genus. Los Angeles County Mus. Contr. Sci., 308:1–17.

Mead, J. I., T. R. Van Devender, K. L. Cole, and D. B. Wake. 1985. Late Pleistocene vertebrates from a packrat midden in south-central Sierra Nevada, California. Current Res. Pleistocene 2:107–108.

———, S. L. Swift, M. Hollenshead, and C. N. Jass. 2000. Preliminary report on the Holocene vertebrates from G3D locality, Oregon Caves National Monument, Oregon. J. Vert. Paleo. 20: 58A.

Orr, P. C. 1968. Prehistory of Santa Rosa Island. Santa Barbara Mus. Nat. Hist., Cal., 253 pp.

Peabody, F. S. 1959. Trackways of living and fossil salamanders. Univ. Cal. Publ. Zool., 63:1–72.

Petranka, J. W. 1998. Salamanders of the United States and Canada. Smithson. Inst. Press, 587 pp.

Philbrick, R. N. 1967. Introduction. Pp. 3–8 *in* Proceedings of the Symposium on the Biology of the California Islands. (R. N. Philbrick, ed.), Santa Barbara Botanic Garden, Cal., 363 pp.

Roth, V. L. 1996. Pleistocene dwarf elephants form the California Islands. Pp. 249–253 *in* The Proboscidea. (J. H. Shoshani and P. Tassy, eds.), Univ. Oxford Press, 472 pp.

Savage, J. M. 1967. Evolution of the insular herpetofaunas. Pp 219–227 *in* Proceedings of the Symposium on the Biology of the California Islands. (R. N. Philbrick, ed.), Santa Barbara Botanic Garden, Cal., 363 pp.

Selvin, J. R. 1928. The amphians of western North America. Occas. Pap. Cal. Acad. Sci. 16:1–144.

Stebbins, R. C. 2003 (3rd. edition). Western reptiles and amphibians. Houghton Mifflin Co., 533 pp.

Stock, C., and E. L. Furlong. 1928. The Pleistocene elephants of Santa Rosa Island, California. Science, 68:140–141.

Tihen, J. A., and D. B. Wake. 1981. Vertebrae of plethodontid salamanders from the lower Miocene of Montana. J. Herpetol., 15:35–40.

Vedder, J. G., and D. G. Howell. 1980. Topographic evolution of the Southern California borderland during Late Cenozoic time. Pp. 7–31 *in* The California Islands: Proceedings of a Multidisciplinary Symposium. (D. M. Power, ed.), Santa Barbara Mus. Nat. Hist., Cal., 787 pp.

Wake, D. B. 1963. Comparative osteology of the plethodontid salamander genus *Aneides.* J. Morph., 113:77–118.

———. 1966. Comparative osteology and evolution of the lungless salamanders, family Plethodontidae. Mem. So. Cal. Acad. Sci., 4:1–111.

———. 1993. Phylogenetic and taxonomic issues relating to salamanders of the family Plethodontidae. Herpetologica, 49:229–237.

———. 1996. A new species of *Batrachoseps* (Amphibia: Plethodontidae) from the San Gabriel Mountains, Southern California. Los Angeles County Mus. Contr. Sci., 463:1–12.

———, and E. L. Jockusch. 2000. Dectecting species borders using diverse data sets: examples from plethodontid salamanders in California. Pp. 95–119 *in* The Biology of Plethodontid Salamanders. (R. C. Bruce, R. G. Jaeger, and L. D. Houck, eds.), Kluwer Adacemic/Plenum Publ., NY, 485 pp.

Wenner, A. M., and D. L. Johnson. 1980. Land vertebrates on the California Channel Islands: sweepstakes or bridges? Pp. 497–530 *in* The California Islands: Proceedings of a Multidisciplinary Symposium. (D. M. Power, ed.), Santa Barbara Mus. Nat. Hist., Cal., 787 pp.

Wilcox, B. A. 1980. Species number, stability, and equilibrium status of reptile faunas on the California Islands. Pp. 551–564 *in* The California Islands: Proceedings of a Multidisciplinary Symposium. (D. M. Power, ed.), Santa Barbara Mus. Nat. Hist., Cal., 787 pp.

Yanev, K. P. 1980. Biogeography and distribution of three parapatric salamander species in coastal and borderland California. Pp. 531–550 *in* The California Islands: Proceedings of a Multidisciplinary Symposium. (D. M. Power, ed.), Santa Barbara Mus. Nat. Hist., Cal., 787 pp.

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Notes on the Systematics of the Crestfish Genus *Lophotus* (Lampridiformes: Lophotidae), with a New Record from California

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Abstract.—On 17 November 1995, a specimen of crestfish, genus *Lophotus,* was collected from northern California. Uncertainty regarding the taxonomy of the genus prompted a review of its systematics. Meristic differences in number of dorsal-fin rays and total vertebrae, whose numerical distributions are largely congruent with geography, suggest that the previous synonymy of all nominal crestfish species was unwarranted. Genetic differences between individuals from the north and south Pacific are consistent with meristic variation and indicate the presence of two largely allopatric species in the Pacific basin. While we are unable to completely resolve the taxonomy of *Lophotus* on a worldwide basis, our study indicates that the eastern and western north Pacific forms are conspecific and distinct from south Pacific *Lophotus.* The oldest available name for a north Pacific crestfish is *Lophotus capellei* Temminck and Schlegel, 1845, thus we consider this to be the valid name for the California species.

The fishes of the order Lampridiformes are represented by 19 species in 12 genera and 7 families (Olney et al. 1993; Nelson 1994). These fishes are some of the most colorful and morphologically diverse teleost fishes, including the oarfish, *Regalecus glesne,* the opah, *Lampris gutattus,* and the unicornfish, *Eumeçichthys fiski.* Included in the Lampridiformes are the crestfishes of the genus *Lophotus* Giorna 1809. Unique among the lampridiforms, *Lophotus* species can extrude a dark "ink" from a specialized gland near the anus (Fitch and Lavenberg 1968). These pelagic fishes inhabit warm seas on a circumglobal scale, and have been recorded from the surface to 300m (Heemstra 1986). They have pelagic egg and larval stages, and juveniles have been taken in plankton tows, both at the surface and at depth, as well as from the stomachs of tuna (Eschmeyer et al. 1983; Charter and Moser 1996).

On 17 November 1995, a 940 mm SL specimen of *Lophotus* was taken by a commercial fishing vessel in a drift gill net, with the locality listed as "off Morro Bay, California." The specimen was given to Dennis Dunn, captain of the R/V *VANTUNA,* while in port at Fish Harbor, San Pedro, California. Captain Dunn released the specimen to Daniel J. Pondella, II, who subsequently deposited the fish at the Scripps Institution of Oceanography Marine Vertebrates Collection (SIO 00-121).

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Collection of this specimen prompted a reexamination of the taxonomy of *Lophotus.* Several nominal species have been described for what may be one or more species. Three of these species (*L. lacepede* Giorna, 1809, *L. capellei* Temminck and Schlegel, 1845, and *L. cristatus* Johnson, 1863) have been recognized most frequently, albeit with questionable certainty, and their usage remains in a state of flux (e.g., Goode and Bean 1895; Boeseman 1947; Goin and Erdman 1951; Briggs 1952; Palmer 1973, 1986; Fujii 1984; Heemstra 1986; Paxton et al. 1989). With few exceptions (Goode and Bean 1895; Goin and Erdman 1951; Briggs 1952), no explicit criteria were presented for most nomenclatural decisions. Although overlooked by most recent treatments, Goin and Erdman (1951) provided the most thorough taxonomic review to date of *Lophotus,* in which they synonymized all nominal species with *L. lacepede,* including the California species treated as *L. cristatus* by Miller and Lea (1972).

Materials and Methods

Meristic data were collected following Hubbs and Lagler (1958). Institutional abbreviations follow Leviton et al. (1985). The dorsal surfaces of several specimens were damaged by the collecting gear, thus counts for 15 individuals were reconfirmed by examination of radiographs. The degree of projection of the forehead was scored as this character has been used to identify species of *Lophotus* (Briggs, 1952). Score ranged from 1 to 3, with 1 being no or nearly no projection, 2 being moderately projecting (i.e., the angle of the straight line from the tip of the upper jaw to the tip of the crest between 15–45° from the vertical line drawn perpendicular to axis of the vertebral column), and 3 being strongly projecting (i.e., the angle described above more than 45° from the vertical line drawn perpendicular to the vertebral column). The confluence of the dorsal and caudal fin was scored (0 = not confluent, 1 = confluent). Photographs of the specimens from the BMNH and the BPBM were suitable for determining crest score, however they were not usable for meristic data.

Materials examined follow ("P" indicates photograph, and "X" indicates X-ray): USA: SIO 00-121 (off Morro Bay, CA), SIO 60-180 (380mi off Pt. Arena, CA), SIO 69-23 (Central Pacific Ocean), SIO 48-245 (Santa Catalina Island, CA), SIO 62-427 (Eastern Pacific), SIO 73-325 (Central North Gyre, Pacific Ocean), SIO 60-548 (Tropical Eastern Pacific, gut contents of tuna), SIO 49-4 (Bel Air Beach, CA), SIO 64-236 (Unknown, probably CA), SIO 88-140 (San Diego, CA), SIO 65-686 (Tanner Bank), LACM 47301-1 (Monterey, CA), LACM 34176 (Los Angeles, CA), USNM 151118 (Clearwater Beach, Florida; X), BPBM 21102 (Oahu, Hawaii; P), BPBM 21106 (Oahu, Hawaii; P), BPBM 28812 (Hawaii; P), MCZ 15531 (North Sargasso Sea; P). Australia: AM I34438-001 (New South Wales; X, P), AM B5776 (Tasmania; X, P), AM I19749-007 (New South Wales; X, P), AM 33329-001 (Norah Head, New South Wales; X, P), AM I26980-001 (New South Wales; X, P), AM 26947-001 (New South Wales; X, P), AM IB7440 (New South Wales; X, P), AM I25631-001 (New South Wales; X, P). South Africa: BMNH 1899.9.5.4 (Mossel Bay; P). Portugal: BMNH 1863.8.27.1 (Madeira; Holotype, *L. cristatus*; P). Unknown locality: BMNH 1852.8.12.40 (P).

Given the uncertainty of the taxonomy within this genus, genetic data were gathered from the Morro Bay specimen (SIO 00-121) to determine divergence from a specimen taken in the Tasman Sea (Wiley et al. 1998). Mitochondrial (MT) rDNA genes have provided considerable insight in identifying species-level differences in various fish groups despite small sample sizes (e.g., Holder et al. 1999; Tringali et al. 1999). Genetic sequence data were gathered following the methods of Craig et al. (2001) with minor modifications. Briefly, total genomic DNA was isolated using DNeasy protocols (Qiagen), and partial sequences for the MT 16S and 12S rDNA genes were obtained using the Polymerase Chain Reaction with universal primers (Palumbi 1996). Data was compared with published sequence data (Wiley et al. 1998; GENBANK accession numbers AF049737, AF049727).

Results

Variation in the number of dorsal-fin rays and total vertebrae showed a strong geographical pattern (Table 1). Most specimens from the north and central Pacific have 210–229 dorsal-fin rays (mode = 229; mean 225.9 ± 13.7; one outlying specimen, NMNH 198226, from Johnston Island had 262) and 123–144 total vertebrae (mode = 126; mean = 132.5 ± 11.3; NMNH 198226 had 153). Specimens from the south Pacific had 225–259 dorsal-fin rays (mode = NA; mean 246 ± 11.25) and 141–152 total vertebrae (mode = 149; mean = 147.2 ± 4.02). In all specimens, anal-fin rays varied from 19–21 (mode = 21; mean = 20.3 ± 0.8), pectoral-fin rays varied from 15–19 (mode = 15; mean = 16.3 ± 1.3), and pelvic-fin rays were consistently five (Table 1). Four post-larval specimens (SIO 60-180, SIO 69-23, SIO 48-245, and MCZ 15531) were examined, however they were badly damaged and no data was suitable for use.

Degree of projection of the forehead appeared to be correlated with body size, with a decreased projection as specimens approached 1 m SL. This pattern was most evident in specimens from the north and central Pacific (Table 1). The degree of separation of the dorsal and caudal fins was impossible to score in virtually all specimens because of damage to these fins.

Considerable genetic differentiation is present between the two specimens of crestfish examined. For the portion of the 16S rDNA gene amplified, 7.3% sequence difference was observed (GENBANK Accession number AY036618), and comparable differentiation (10.8%) was found in the 12S locus (GENBANK Accession number AY036616).

Discussion

The first American specimen of *Lophotus* was reported by Higgins (1920) from Long Beach, California. Subsequent California records are sporadic, with individuals taken at Tanner Bank (Fitch 1966), San Diego (SIO 88-140), Santa Catalina Island (Fitch 1952), San Pedro (LACM 34176-1), Santa Monica Bay (Fitch and Lavenberg 1968), and Point Dume (Miller and Lea 1972). Many adult specimens were collected after being washed ashore or captured while observed swimming at the surface. Although published records, many of these collections are anecdotal and voucher specimens were presumably never deposited in museum collections. More recently, the drift gill net fishery north of Pt. Conception reported several specimens during the 1990's (R. N. Lea, pers. comm.), including a 970 mm SL specimen taken in a drift gill net (LACM 47301-1).

Table 1. Meristics for specimens of *Lophotus.* "*" Indicates lack of data resulting from specimen damage and/or unavailability of radiograph.

Specimen number	Locality	Standard length	Dorsal rays	Anal rays	Pectoral rays	Pelvic rays	Vertebrae	Crest score
	North/Central Pacific Ocean							
SIO 62-427	Eastern Pacific, off California	42	214	19	15	5	126	*
SIO 73-325	Central North Pacific	47	229	*	*	5	144	*
SIO 60-548	Tropical Eastern Pacific	270	*	21	18	*	123	3
SIO 88-140	San Diego, California	642	220	*	16	5	*	3
LACM 34176-1	Los Angeles, California	758	227	21	15	5	126	3
SIO 49-4	Bel Air Beach, California	862	221	*	15	5	*	3
SIO 64-236	Tropical Eastern Pacific	924	223	*	15	5	*	3
SIO 00-121[S]	Morro Bay, California	940	218	20	19	5	128	2
LACM 47301-1	Pt. Sur, California	970	216	*	15	*	*	2
SIO 65-686	Tanner Bank	1000	229	21	16	5	128	2
BPBM 21102	Oahu, Hawaii	1216	*	*	*	*	*	1
BPBM 28812	Hawaii	1252	*	*	*	*	*	1
BPBM 21106	Oahu, Hawaii	1256	*	*	*	*	*	1
NMNH 198226	Johnston Island	>1200	262	21	16	5	153	1
	South Pacific Ocean							
AM I19749-001	New South Wales	115	225	20	16	*	141	3
AM 33329-001	Norah Head, New South Wales	790	254	21	15	5	149	1
AM B5776[$]	Tasmania	968	*	*	17	*	*	2
AM I26980-001	New South Wales	980	259	19	18	5	152	1
AM I25631-001	New South Wales	1040	252	19	18	5	145	1
AM IB7440	New South Wales	1070	247	21	18	5	151	1
AM I34438-001[S]	New South Wales	1120	246	21	*	*	144	2
AM 26947-001	New South Wales	1225	239	21	16	5	149	2
	Atlantic Ocean							
BMNH 1863.8.27.1+	Madeira, Portugal	~860	*	*	*	*	*	3
BMNH 1899.9.5.4	Mossel Bay, South Africa	?	*	*	*	*	*	1
USNM 151118	Clearwater Beach, Florida	828	242	20	*	5	138	1
	Unknown Locality							
BMNH 1852.8.12.40	Unknown	~880	*	*	*	*	*	2

"+" Holotype of *L. cristatus.*
"$" Holotype of *L. guntheri.*
"S" Sequence data available.

The numerous occurrences of *Lophotus* during the 1990's in northern California mark the first records of this fish North of Point Conception, and represent a substantial northward range extension (previously Pt. Dume; Miller and Lea 1972). Point Conception is considered a well-established faunal break, dividing the Californian and Oregonian faunal provinces (e.g., Brusca and Wallerstein 1979), yet this faunal break may not represent a significant barrier to pelagic fishes such as *Lophotus*. Nevertheless, it is interesting to note the occurrence of crestfish in both the sub-tropical/temperate Californian province and the cold-water Oregonian province. Presence of crestfish north of Point Conception may have gone unnoticed or may represent a northward range expansion precipitated by the persistent warm water conditions observed along the California coast during this time period initiated by the strong El Niño Southern Oscillation event of 1992–93.

While previous nomenclatural inconsistencies within *Lophotus* are a result of an inadequate amount of comparative material, the absence of type specimens for many nominal species, and the world-wide distribution of the group, the confusion surrounding the taxonomy of the genus also reflects the indirect and non-latinized naming of the type specimen for *Lophotus* (Giorna 1809; for a complete discussion, see Goin and Erdman 1951). Although Goin and Erdman (1951) considered *Lophotus* to be monotypic, our review of the literature, coupled with genetic data and examination of museum specimens, indicate that there are at least three species of *Lophotus*.

Goode and Bean (1895) recognize three species based on coloration and two morphometric characters, degree of connection of the dorsal and caudal fins, and shape of the cranial crest (Figure 1). A strongly projecting forehead and well-separated dorsal and caudal fins are reportedly diagnostic of *L. lacepede* (as *L. cepedianus*), whereas a blunt forehead and continuous dorsal and caudal fins are diagnostic of *L. capellei* and *L. cristatus* (Goode and Bean 1895). Briggs (1952) also concluded that the strongly projecting forehead was diagnostic of *L. lacepede*. His conclusions were based on line drawings from early (ca 1900) publications. We noted that the degree of forehead projection is reduced in larger specimens, particularly among specimens from the north/central Pacific (Table 1). This pattern is less clear in specimens from other regions. Nonetheless, the clear reduction seen in the size of the forehead crest in adults approaching 1 m SL from the north Pacific, together with the presence of a well-developed crest in postlarval specimens, indicate that this character should be used with caution for diagnosing species of crestfishes.

The confluence of the dorsal and caudal fins is difficult to interpret as collection gear usually damages specimens and a tear is difficult to distinguish from an actual separation. However, radiographs show that these two fins are consistently separated in that the dorsal pterygiophores do not extend the entire length of the dorsal surface. The lack of pterygiophores, however, does not rule out the possibility of the presence of a membrane lacking rays that connects the dorsal and caudal fins. Briggs (1952) also indicated that the dorsal fin is considerably shorter just posterior to the elongated first dorsal-fin ray in *L. capellei* compared to *L. lacepede*. We have found evidence of this phenomenon in photographs of fresh specimens from both the north and south Pacific and this character is difficult to score in damaged specimens.

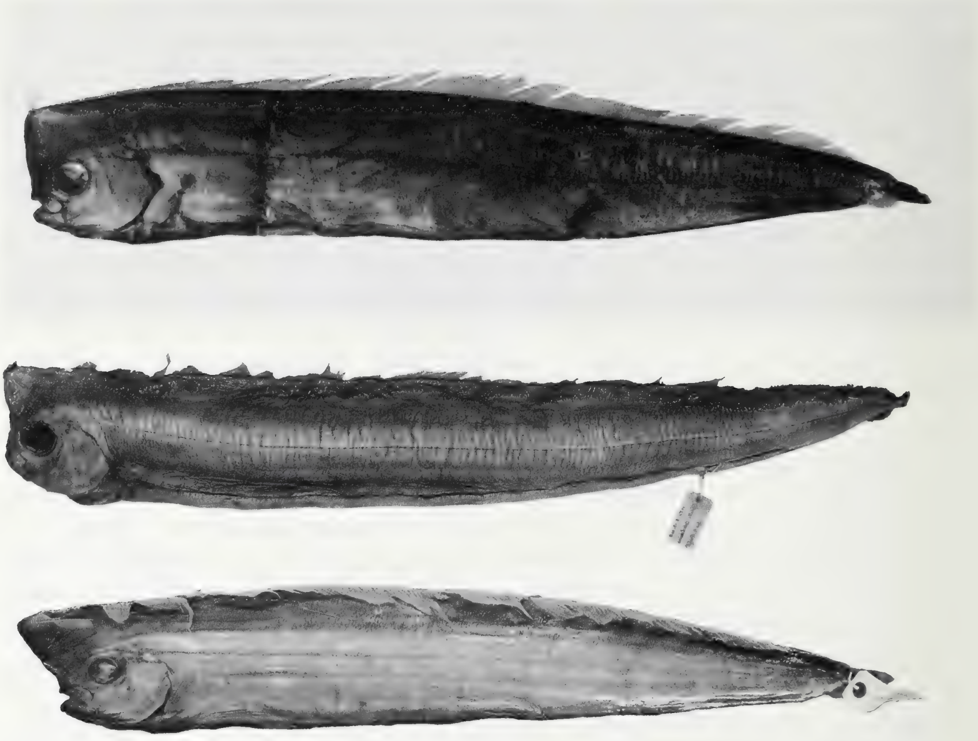

Fig. 1. Variation in forehead crest of *Lophotus* spp. (Top) *Lophotus* sp. (USNM 151118) displaying the blunt forehead character (score 1). Photograph provided courtesy of NMNH. The individual was captured at Clearwater Beach, Florida. (Middle) *Lophotus* sp. (BMNH 1852.8.12.40) displaying the intermediate forehead crest (score 2). The individual is of unknown locality. (Bottom) *Lophotus capellei* (LACM 34176-1) displaying the projecting forehead (score 3). The individual was captured outside of the Los Angeles Harbor, California.

In reviews of three nominal species *L. lacepede, L. cristatus,* and *L. capellei,* Goode and Bean (1895) describe *L. lacepede* as "... silvery gray, with rounded spots of silver, which are brighter than the body itself." They describe *L. cristatus* as "... silvery gray without spots" and *L. capellei* as "... pale blue, becoming white on the lower parts and blackish blue upon the head." Photographs of recent specimens from the Mediterranean Sea (the type locality for *L. lacepede*) have a spotting pattern, although the background of the fish is more of a drab brown than silvery gray as described by Goode and Bean (1895; Ragonese et al. 1997). Photographs of specimens from New Zealand, Australia, Hawaii, and California have distinct silver background coloration, but lack spots.

The observed genetic differentiation between the two specimens of *Lophotus* for which data is available provides evidence of two distinct species in the Pacific basin. Genetic data for the stomiiform fish genus *Gonostoma,* which shares a circumglobal distribution and pelagic habitat with *Lophotus,* demonstrates similar levels of genetic differentiation between clearly distinct species (Miya and Nishida 2000). This level of genetic differentiation at the species level has also been demonstrated for several shore fishes (e.g., Craig et al. 2001). Meristic data (dorsal-fin ray and vertebral counts; Table 1) corroborates the genetic data and implies the occurrence of two species, one in the northern Pacific and one in the southern Pacific. Three outlying specimens examined (NMNH 198226, SIO 73-325, and AM I19149-001) warrant brief mention. The specimen from Johnston Island (NMNH 198226) had both high dorsal-fin ray and vertebral counts consistent with the south Pacific form, while SIO 73-325 from the central gyre of the north Pacific had vertebral counts consistent with the south Pacific form. Although this specimen has low dorsal-fin ray counts, it is a late-stage larvae (47 mm SL) and most likely does not have a full compliment of dorsal-fin rays. A third outlying specimen from New South Wales (AM I19749-001) had a low dorsal-fin ray count (225), typical of the north Pacific form, yet had a vertebral count more typical of the south Pacific form (141). Additional genetic and morphological data are needed to evaluate the existence of other species of *Lophotus,* particularly from the Western Atlantic and Mediterranean from which specimens are scarce.

Conclusions

Systematics of the genus *Lophotus* have been confounded by the absence of type specimens, lack of comparative material, and the oversight of previous taxonomic treatments. Our investigation concludes that, taken alone, two heretofore widely used characters (forehead shape and continuity of the dorsal and caudal fins) are not useful for diagnosing *Lophotus* species. In light of the genetic variation seen in the individuals examined, and given the different distributions of meristic counts congruent with the genetic differences, we conclude that there are two species of *Lophotus* in the Pacific basin. Specimens examined from the south Pacific typically have 239–259 dorsal-fin rays and 141–152 total vertebrae, while most specimens examined from the north Pacific have 214–229 dorsal-fin rays and 123–144 total vertebrae. The rare occurrence of crestfishes in the north Pacific with counts more typical of the south Pacific form (e.g., NMNH 198226 from Johnston Island; Table 1) may imply that these species are not entirely allopatric. We have examined few specimens from the Atlantic basin and genetic data from that region are unavailable. Some specimens from this area exhibit a distinctive color pattern (lateral spots) while other lack these spots (e.g., McEachran and Fechhelm 2000).

The oldest available name for a species of crestfish is *Lophotus lacepede* Giorna 1809, type locality Mediterranean Sea. Because Goode and Bean (1895) mention lateral spots as first reviewers of this species, and in light of recent photographs of specimens from the Mediterranean Sea bearing these spots, we conclude that this name applies to the spotted form in the Atlantic basin. At this time, we are unable to resolve the status of Atlantic-basin specimens lacking spots (McEachran and Fechhelm 2000). If distinct from the spotted form, the nominal species *L. cristatus* Johnson 1863, (type locality Madeira, eastern Atlantic) which lacks spots (Goode and Bean 1895), may apply to this form. The oldest available name for a Pacific crestfish is *Lophotus capellei* Temminck and Schlegel 1845, type locality “Seas of Japan.” Because of the similar meristic counts for *Lophotus* specimens examined from the eastern north Pacific and those taken from the original species description of *L. capellei,* we consider the eastern Pacific form to also be *L. capellei.* The oldest available name for a crestfish from the south Pacific is *L. guntheri* Johnston 1882 (considered a synonym of *L. capellei* by Paxton et al. 1989) type locality Tasmania. However, the appropriate name for Pacific crestfishes with high dorsal-fin ray and vertebral counts depends upon its status relative to Atlantic crestfishes. The numerous occurrences of the north pacific crestfish, *Lophotus capellei,* in northern California during the 1990's warrant the addition of this species to the region's ichthyofauna.

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Literature Cited

Boesman, M. 1947. Revision of the fishes collected by Burger and Van Siebold in Japan. Zool. Meded. (Leichen) Vol. 28.

Briggs, J. C. 1952. Systematic notes on the oceanic fishes of the genus *Lophotus.* Copeia 1952(3): 206–207.

Brusca, R. C., and B. R. Wallerstein. 1979. Zoogeographic patterns of idoteid isopods in the northeast Pacific, with a review of shallow-water zoogeography for the area. Bull. Biol. Soc. Wash. 3:67–105.

Charter, S. R. and H. G. Moser. 1996. Lophotidae, In: The Early Stages of Fishes in the California Current Region. H. G.. Moser, ed. CalCOFI Atlas No. 33, Allen Press, Inc., Lawrence, Kansas. xii + 1505 pp.

Craig, M. T., D. J. Pondella, J. P. C. Franck, and J. C. Hafner. 2001. On the status of the serranid fish genus *Epinephelus*: Evidence for paraphyly based on 16S rDNA sequence. Mol. Phy. Evol. 19(1):121–130.

Eschmeyer, W. N., E. S. Herald, and H. Hammann. 1983. A field guide to Pacific coast fishes of North America. Houghton Mifflin Company. Boston. p. v–xi, 336 pp.

Fitch, J. E. 1952. Distributional note on some Pacific coast marine fishes. Cal. Fish and Game Bull. 38(4):557–564.

———. 1966. A marine catfish, *Bagre panamensis* (Gill), added to the fauna of California, and other anomalous fish occurrences off southern California in 1965. Cal. Fish and Game Bull. 52(3): 214–215.

———, and R. J. Lavenberg. 1968. Deep Water Teleostean Fishes of California. Univ. Calif. Press. Berkeley and Los Angeles. 155 pp.

Fujii, E. 1984. In: Fishes of the Japanese archipelago. H. Masuda, K. Amaoka, T. Uyeno, and T. Yoshino, eds. Tokai University Press. pp, i–xxii, 1–437.

Giorna, M. E. 1809. Mémoire sur des poisons d'espécies nouvelles et de genres nouveaux. Mem. Acad. Imp. Sci. Lit. Beaux-arts. Turin. 9(1):1–19, 177–180.

Goin, J. C., and D. S. Erdman. 1951. The crested oarfish, *Lophotus lacepede,* from Florida; First record for the western north Atlantic. Copeia 1951(4):285–287.

Goode, G. B., and T. H. Bean. 1895. Oceanic ichthyology, a treatise on the deep-sea and pelagic fishes of the world based chiefly upon the collections made by the steamers Blake, Albatross, and Fish Hawk in the North-west Atlantic, with an atlas containing 417 figures. USNM Special Bulletin No. 2.

Heemstra, P. C. 1986. Lophotidae, In: Smith's Sea Fishes, M. M. Smith and P. C. Heemstra, eds. Springer-Verlag. 1047 pp.

Higgins, E. 1920. First appearance of the "Crested Band-Fish." Cal. Fish and Game 6(1):34–35.

Holder, M. T., M. V. Erdman, T. P. Wilcox, R. L. Caldwell, and D. M. Hillis. 1999. Two living species of coelacanth? Proc. Nat. Acad. Sci. 96(22):12616–12620.

Hubbs, C. L., and K. F. Lagler. 1958. Fishes of the great lakes region. Cranbrook Inst. Sci. Bull. No. 26, Bloomfield Hills, Michigan.

Johnson, J. Y. 1863. Description of 5 new species obtained at Madeira. Proc. Zool. Soc. Lond. 1863 pt. 1:36–46.

Johnston, R. M. 1882. Description of a new species of fish caught near Emu Bay, Tasmania. Pap. Proc. R. Soc. Tasmania. 1882:176–178.

Leviton, A. E., R. H. Gibbs, Jr., E. Heal, and C. E. Dawson. 1985. Standards in herpetology and ichthyology. Part I. Standard symbolic codes for institutional resources collections in herpetology and ichthyology. Copeia 1985(3):802–832.

McEachran, J. D., and J. D. Fechhelm. 2000. Fishes of the Gulf of Mexico. Volume 1. University of Texas Press, Austin. 1112 pp.

Miller, D. J., and R. N. Lea. 1972. Guide to the coastal marine fishes of California. Cal. Fish Bull. No. 157. 249 pp.

Miya, M., and M. Nishida. 2000. Molecular systematics of the deep-sea fish genus *Gonostoma* (Stomiiformes; Gonostomatidae): Two paraphyletic clades and resurrection of *Sigmops*. Copeia 2000(2):378–389.

Nelson, J. S., 1994. Fishes of the World. 3rd edition. John Wiley and Sons, Inc. New York. 600 pp.

Olney, J. E., G. D. Johnson, and C. C. Baldwin. 1993. Phylogeny of lampridiform fishes. Bull. Mar. Sci. 52(1):137–169.

Palmer, G. 1973. Lophotidae, In: Check list of the fishes of the north-eastern Atlantic and of the Mediterranean (CLOFNAM). Hureau, J. C., and T. Monod, eds. UNESCO, Paris. p. i–xiii, 1–683.

———. 1986. Lophotidae, In: Fishes of the North-eastern Atlantic and the Mediterranean. P. J. P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen, and E. Tortonese, Eds. UNESCO.

Palumbi, S. R. 1996. In: Hillis, D. M., C. Moritz, and B. K. Mable (eds.). Molecular Systematics. Sinauer Associates, Inc. Sunderland, Mass. 655 pp.

Paxton, J. R., D. F. Hoese, G. R. Allen, and J. E. Henley. 1989. Zoological Catalogue of Australia. V. 7. Pisces: Petromyzontidae to Carangidae. Australian Government Publishing Service, Canberra. p. i–xii, 665 pp.

Ragonese, S., P. Jereb, and U. Morara. 1997. Su di un esemplare di pesce liocorno *Lophotus lacepedei* (Lampridiformes-Lophotidae) speaggiato a mazara del vallo (Sicilia sud occidentale). Biol. Mar. Medit. 4(1):551–553.

Temminck, C. J., and H. Schlegel. 1845. Pisces, In: Fauna Japanica sive description animalium quae in itinare per Japonicam sucscepto annis 1823–30 collegit, notis observationibus et adumbrationibus. . . Part 1, pgs. 1–20. (Not seen).

Tringali, M. D., T. M. Bert, S. Seyoum, E. Bermingham, and D. Bartolacci. 1999. Molecular phylogenetics and ecological diversification of the transisthmian fish genus *Centropomus* (Perciformes: Centropomidae). Mol. Phy. Evol. 13(1):193–207.

Wiley, E. O., G. D. Johnson, and W. W. Dimmick. 1998. The phylogenetic relationships of Lampridiform fishes (Telesotei: Acanthomorpha), based on a total-evidence analysis of morphological and molecular data. Mol. Phy. Evol. 10(3):417–425.

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Allozyme Evidence of the Bigeye Croaker (*Micropogonias megalops*) Fishery Collapse in the Upper Gulf of California

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Abstract.—Allozyme analysis was used to study the genetic variability of the bigeye croaker *Micropogonias megalops* in the Upper Gulf of California (UGC). Samples of 55 and 65 individuals were collected from commercial fishing zones in the UGC. Starch gel electrophoresis of proteins was used. Fourteen enzymatic systems were analyzed and 30 loci were detected. All polymorphic loci were outside of the Hardy-Weinberg equilibrium and the inbreeding coefficient (*Fis*) was 86%. Allozyme indicators were considered low for the population and indicate erosion in the genetic variability. Commercial fishing catch represents a population impact. A fishery management plan incorporated into the traditional economic activities is a proposal to assure this fishery resource.

The bigeye croaker, *Micropogonias megalops* (Gilbert), is a coastal bottom-dwelling species, and is one of the 100 reported species of the family Sciaenidae in the eastern Pacific. Members of the family are an important component in the coastal fisheries catch in the eastern Pacific (Chao 1995). The bigeye croaker has a restricted distribution (Allen and Robertson 1994; Chao 1995) and was formally considered endemic to the Gulf of California (Castro-Aguirre 1978). The fishery formally began in the Upper Gulf of California (UGC) in the 1990s (Cudney-Bueno and Turk-Boyer 1998) with a maximum capture of 5,200,000 kg and a sudden decrease at the end of the decade to 1,500,000 kg. The bigeye croaker fishery was developed as a socioeconomic alternative to the prohibited totoaba fishery, *Totoaba mcdonaldi,* and the low capture rate of shrimp. The high demand for bigeye croaker by the Korean surimi industry supported the fishery and reduced the social problem caused by the depletion of the traditional fishery-capture species (Cudney-Bueno and Turk-Boyer 1998). Unpublished fishery studies of bigeye croaker suggest instituting a catch reduction as a precautionary measure to avoid overexploitation (Román-Rodríguez et al. 2000). However lack of fishery regulations is allowing declining catches, and the lack of knowledge of the abundance and population structure imperils its permanency and stability in the UGC. This fishery is being depleted.

Molecular indicators of bigeye croaker population structure are nonexistent. Genetic studies of other sciaenid species in the Pacific and Atlantic coasts are available, but are inappropiate for comparisons (Bartley and Kent 1990; Beckwitt 1983; Levy et al. 1998; Suzuki et al. 1983; Ramsey and Wakeman 1987; Wakeman and Ramsey 1988; Gold et al. 1988, 1993; Bohlmeyer and Gold 1991; Gold and Richardson 1994; Crawford et al. 1988; Ramsey and Wakeman 1987).

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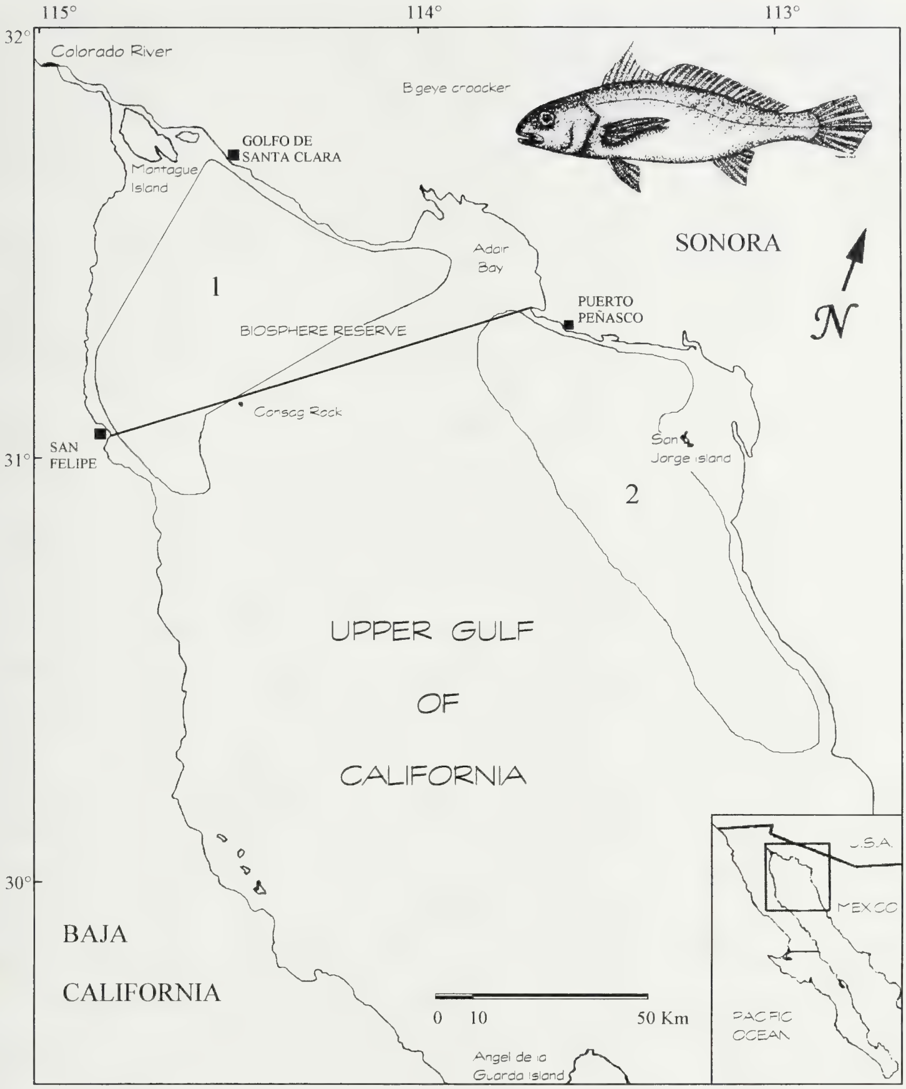
115°
114°
113°
32°
31°
30°
Colorado River
Bigeye croacker
GOLFO DE SANTA CLARA
Montague Island
SONORA
Adair Bay
1
PUERTO PEÑASCO
N
BIOSPHERE RESERVE
Consag Rock
SAN FELIPE
San Jorge island
2
UPPER GULF OF CALIFORNIA
BAJA CALIFORNIA
0 10 50 Km
Angel de la Guarda Island
U.S.A.
MEXICO
PACIFIC OCEAN

Fig. 1. Sampling sites (1, 2) of bigeye croaker *Micropogonias megalops* in the Upper Gulf of California. Thick line represents the southern limit of the UGCRBR.

Data related to fisheries, genetic variability, and population structure of bigeye croaker are necessary to design an effective capture effort for the management of the fishery. This paper evaluates the allozyme variability of bigeye croaker in the UGC to lay the foundations for management and conservation.

Methods

One hundred and thirty specimens of *M. megalops* were collected from the commercial fishery in the UGC. Fifty-five specimens were collected in April 1998 in fishing zone 1 (Fig. 1), where a fishery of outboard-motor boats that use 100-mm gill nets operates. This fishery has its base in El Golfo de Santa Clara, Sonora, inside the Upper Gulf of California and Colorado River Delta Biosphere Reserve

(UGCRBR). Sixty-five fish were collected from January to March 1999 from fishing zone 2, where a bottom-gear trawler fishery based in Puerto Peñasco, Sonora operates, outside of the UGCRBR, using 100-mm nets. Tissue samples of skeletal muscle, liver, heart, and eyes were taken from each fish, frozen at −20 °C in the field, stored at −70 °C in the laboratory, and analyzed for allozyme variation.

Approximately five grams of muscle and liver, and the whole heart and eyes were macerated individually in an equal volume of 0.1 M TRIS.HCl, pH 8.0, NAD, NADP, and Polyvinyl-pyrrolidone solution (100:0.1:0.1:1, v:w:w:w), and homogenates were centrifuged at 3500 rpm for 20 minutes at 4 °C. The extracts were stored at −70 °C until analysis. Horizontal 12% starch (Sigma S4501) gel electrophoresis (Aebersold et al. 1987) was used in the analysis of 20 enzymatic systems with four buffer solutions (Table 1). Preliminary screening resolved 47 loci, and at least 30 loci showed enough activity and good resolution to be genetically interpreted for each sampled zone (Table 1). Grant and Utter (1980) and Grant et al. (1984) were followed for the zymogram interpretation. Locus nomenclature follows Shaklee et al. (1990), which designates the loci in ascending order beginning with number 1 for the most cathodal locus. A locus was considered polymorphic if the frequency of the most common allele did not exceed 0.95. Alleles for polymorphic loci were designated by relative electrophoretic mobility with the most common allele at each locus designated as "*100*".

Data from zymograms were analyzed with BIOSYS-1 (Swoford and Selander 1981) and Genepop (Raymond and Rousset 1995). Genetic variability was assessed using the mean heterozygosity (Ho) and the unbiased estimate of mean expected heterozygosity per locus under random mating (He) (Nei 1978), and the proportion of polymorphic loci (P). Deviations of genotype frequencies from those expected under Hardy-Weinberg equilibrium hypothesis was tested for all polymorphic loci by means of a Chi-square test, pooling genotypes when more than two alleles were observed. All Chi-square tests were appropriately corrected for multiple tests with the sequential Bonferroni procedure (Rice 1989). Genetic similarity and distance (Nei 1978) between fishing zones were calculated. An evaluation of deficiency and excess of heterozygosity was made by $D = (Ho - He)/He$. The standardized variance in allelic frequencies (F_{ST}), the inbreeding coefficient (F_{IT}), and the inbreeding coefficient in the fishing zones (F_{IS}) were calculated to assess inbreeding and genetic differentiation among fishing zones (Wright 1965). The null hypothesis $F_{IS} = 0$ was tested by means of $\chi^2 = F_{IS}^2 n$, with $k(k-1)^2$ degrees of freedom, where "n" is the sample size and "k" denotes number of alleles (Li and Horvitz 1953). The null hypothesis $F_{ST} = 0$ was tested by means of $\chi^2 = 2NF_{ST}(k-1)$, with $(s-1)(k-1)$ degrees of freedom, where "N" is the number of individuals, "s" is the number of geographic locations and "k" the number of alleles (Workman and Niswander 1970). To prove genotypic independence, χ^2 analysis among pairs of polymorphic loci was carried out (Weir 1996). The heterogeneity of allelic frequencies at polymorphic loci was tested with the log-likelihood ratio test (*G*-test) with Yates's correction for continuity (Zar 1984). The number of migrants per generation was estimated by $N_e m = (Fst^{-1} - 1)/4$ (Hartl 1988).

Table 1. Enzymatic systems assayed, buffers, detected and analyzed loci, and tissues of the bigeye croaker *M. megalops* in the Upper Gulf of California. N.C.E. = Enzyme Commission Number (IUBNC 1984); (−) Loci analyzed. Buffers: A = TRIS Citrate 7.0 (Ayala et al. 1973); B = TRIS Malate 7.4 (Selander et al. 1971); C = TRIS Citrate 8.0 (Selander et al. 1971), D = TRIS Citrate 8.7 (Poulik 1957); E = TRIS EDTA Borate 8.0 (Shaw and Koen 1968). Stain: 1 = Shaw and Prasad (1970); 2 = Shcaal and Anderson (1974); 3 = Abreu-Grobois (1983); 4 = Rosa-Velez (1986).

Enzymatic systems	N.C.E.	Locus	Tissue	Buffer	Stain
Aspartate aminotransferase	2.6.1.1	− _AAT-1*_	Liver	D	2
		− _AAT-2*_	Heart		
		AAT-3*	Liver		
Acid phosphatase	3.1.3.2	− _ACP*_	Liver	D	1
Alcohol dehydrogenase	1.1.1.1	− _ADH-1*_	Liver	B	1
		ADH-2*	Eye		
		ADH-3*	Eye		
Alkaline phosphatase	3.1.3.1	− _AKP*_	Liver	D	1
Esterase	3.1.1.–	− _EST-2*_	Liver	E	1
		− _EST-3*_	Liver		
		− _EST-5*_	Muscle		
Glycerol-3-phosphate dehydrogenase	1.1.1.8	_G3PDH-1*_	Muscle	E	2
		− _G3PDH-2*_	Muscle		
		− _G3PDH-3*_	Liver		
Glucose-6-phosphate dehydrogenase	1.1.1.49	_G6PDH-1*_	Liver	A	2
		G6PDH-2*	Liver		
Glyceraldehyde-3-phosphate dehydrogenase	1.2.1.12	_GAPDH*_	Muscle	C	2
Glutamate dehydrogenase	1.4.1.3	− _GDH-1*_	Liver	E	2
		− _GDH-2*_	Muscle		
		− _GDH-3*_	Liver		
		GDH-4*	Muscle		
Glucose-6-phosphate dehydrogenase	5.3.1.9	_GPI-1*_	Liver	C	1
		GPI-2*	Muscle		
Isocitrate dehydrogenase	1.1.1.42	− _IDH-1*_	Liver	B	3
		IDH-2*	Liver		
Lactate dehydrogenase	1.1.1.27	− _LDH-1*_	Eye	C	1
		− _LDH-2*_	Eye		
Malic enzyme	1.1.1.40	_MEZ*_	Muscle	B	2
Malate dehydrogenase	1.1.1.37	− _MDH-1*_	Eye	C	1
		− _MDH-2*_	Eye		
Octanol dehydrogenase	1.1.1.73	_ODH-1*_	Liver	B	1
		ODH-2*	Liver		
Phosphoglucomutase	5.4.2.2	_PGM*_	Muscle	C	2
General protein	—	− _PTO-1*_	Muscle	D	4
		− _PTO-2*_	Muscle		
		− _PTO-3*_	Muscle		
		− _PTO-4*_	Muscle		
		− _PTO-5*_	Muscle		
Sorbitol dehydrogenase	1.1.1.14	_SDH-1*_	Muscle	E	2
		− _SDH-2*_	Liver		
		− _SDH-3*_	Muscle		
		− _SDH-4*_	Liver		
Superoxide dismutase	1.15.1.1	− _SOD*_	Liver	E	1
Xanthine dehydrogenase	1.1.1.204	_XDH-1*_	Eye	E	2
		− _XDH-2*_	Liver		
		− _XDH-3*_	Muscle		
		− _XDH-4*_	Liver		

Table 2. Genetic variability of the bigeye croaker *M. megalops* in two fishing zones of the Upper Gulf of California.

	Santa Clara	Puerto Peñasco
Number of specimens	55	65
Number of analyzed loci	30	30
Number of polymorphic loci (0.95)	4	4
% polymorphic loci	13.33	13.33
Average number of alleles per locus	1.50 ± 0.20	1.53 ± 0.18
Sample size per locus	51.6 ± 0.80	61.7 ± 1.20
Mean heterozygosity		
Observed	0.012 ± 0.007	0.008 ± 0.005
Expected	0.070 ± 0.032	0.060 ± 0.029

Results

Forty-seven loci from 20 enzymatic systems were detected. Thirty loci from 14 enzymatic systems showed suitable activity for consistent scoring (Table 1). The loci *EST-2**, *EST-3**, *XDH-2**, and *SOD** were polymorphic and the rest were monomorphic. Table 2 summarizes the genetic variation from both locations. The total average sampled size was 56.7 ± 1.00. Total observed and expected heterozygosity were 0.010 ± 0.006 and 0.050 ± 0.030. The average number of alleles per locus was 1.50 ± 0.80. Polymorphism of 13% was recorded for both fishing zones.

All polymorphic loci significantly deviated from the equilibrium of Hardy-Weinberg before and after the correction for multiple simultaneous tests using the sequential Bonferroni procedure. Heterozygote deficiency for all polymorphic loci was detected and values were from −1.000 to −0.442 for both fishing zones. According to Fisher exact test, nine pairs of loci had linkage disequilibrium in all samples (*MDH-1/MDH-2**, *MDH-1*/LDH-1**, *MDH-1*-2/EST-3**, *MDH-1*/XDH-1**, *LDH-1*/XDH-1**, *MDH-1*/ADH-1**, *MDH-2*/ADH-2**, *LDH-1*/ADH-1**, *MDH-1*/SOD**).

The absence of the faster allele *EST-2*114* was detected for fishing zone 2 (Table 3). Monomorphic loci *MDH-1**, *MDH-2**, and *LDH-1**, which did not show enough variation to reach the 0.95 criterion, showed the indistinct absence of low frequency alleles between fishing zones.

The analysis of heterogeneity of allelic frequencies showed *EST-2** and *XDH-2** with highly significant differences and a total $G = 25.206$ ($P<0.001$), which means a strong difference between fishing zones (Table 4). The overall genetic identity between fishing zones varied between 1.000 and 0.888 and the genetic distance from 0.000 to 0.119 for all polymorphic loci. The weighted average *Fis* was 0.862 and the weighted average *Fst* was 0.027, both different from zero, and *Fit* was 0.849 (Table 4). Using the *Fst* value, the estimated number of migrants per generation was 9 migrants every generation.

Discussion

The mean heterozygosity (Ho) can be used to evaluate population structure in coastal fisheries. Comparison of mean Ho between different species at different times results in imprecise conclusions for fishery management. However, the Ho

Table 3. Allelic and phenotypic frequencies, and heterozygosity under the Hardy-Weinberg equilibrium for the polymorphic loci of the bigeye croaker *M. megalops* in the Upper Gulf of California. Loc = Locality; SC = Santa Clara; PP = Puerto Peñasco. * = $P < 0.05$.

		Allelic frequencies						Heterocygosity			Phenotypic frequencies		
Locus	Loc	*93*	*96*	*100*	*104*	*109*	*114*	Ob	Exp	Phenotype	Obs	Exp	χ^2
*EST-2**	SC	0.100	0.382	0.382	0.055	0.018	0.064	0.164	0.697	100/100	19	7.899	126.00*
	(55)									110/114	4	2.697	
										114/114	0	0.193	
										114/96	3	2.697	
										96/96	19	7.899	
										96/109	1	0.771	
										93/93	5	0.505	
										93/109	1	0.202	
										109/109	0	0.009	
										104/104	3	0.138	
	PP	0.040	0.254	0.484	0.032	0.190	0.000	0.063	0.668	100/100	30	14.640	141.27*
	(63)									100/109	1	1.952	
										96/96	15	3.968	
										96/109	2	1.024	
										93/93	2	0.080	
										93/109	1	0.160	
										104/104	12	2.208	
		98	*100*	*103*									
*EST-3**	SC	0.127	0.818	0.055				0.000	0.314	100/100	45	36.743	95.31*
	(55)									103/103	7	0.835	
										98/98	3	0.138	
	PP	0.092	0.877	0.031				0.000	0.223	100/100	57	49.930	107.15*
	(65)									103/103	6	0.512	
										98/98	2	0.047	

Table 3. Continued.

		Allelic frequencies						Heterocygosity			Phenotypic frequencies		
Locus	Loc	*93*	*96*	*100*	*104*	*109*	*114*	Ob	Exp	Phenotype	Obs	Exp	χ^2
		95	*100*	*111*									
*XDH-2**	SC	0.302	0.585	0.113				0.000	0.559	100/100	31	18.010	97.75*
	(53)									95/95	16	4.724	
										111/111	6	0.629	
	PP	0.560	0.380	0.060				0.000	0.544	100/100	19	7.101	88.25*
	(50)									95/95	28	15.556	
										111/111	3	0.152	
		71	*100*	*148*									
*SOD**	SC	0.209	0.745	0.045				0.402	0.145	100/100	37	30.468	41.57*
	(55)									100/148	1	3.761	
										100/71	7	17.303	
										148/148	2	0.092	
										71/71	8	2.321	
	PP	0.109	0.875	0.016				0.125	0.224	100/100	52	48.945	13.71*
	(64)									100/148	2	1.764	
										100/71	6	12.346	
										148/148	0	0.008	
										71/71	4	0.717	

Table 4. Chi-square test for the analysis of heterogeneity of allelic frequencies and *F*-statistics for the polymorphic loci of bigeye croaker *M. megalops* in the Upper Gulf of California. *G* = log-likelihood ratio test, Ns = $P > 0.05$; * = $0.01 < P < 0.05$; ** = $0.001 < P < 0.01$; *** = $P < 0.001$.

Locus	Alleles	*G*	*Fis*	χ^2	*Fit*	*Fst*	χ^2
*EST-2**	6	14.072**	0.832	408.12***	0.835	0.019	22.42*
*EST-3**	3	0.535 ns	1.000	240.00***	1.000	0.005	2.40 ns
*XDH-2**	3	7.151**	1.000	206.00***	1.000	0.049	20.19**
*SOD**	3	3.446 ns	0.564	75.71***	0.589	0.022	10.47**
TOTAL	15	25.206***	0.862	930.12***	0.849	0.027	55.48**

of *M. megalops* (0.010 ± 0.006) in the UGC was low compared to the Ho reported by Nevo (1978) (0.051 ± 0.003) for 60 and Ward et al. (1994) (0.064 ± 0.004) for 57 marine fish species, and to the estimates proposed by Smith and Fujio (1982) (0.055 ± 0.036) for 106 marine teleost species. Though comparisons with other underexploited populations of the sciaenid family are not valid, *Cynoscion nebulosus* has a lower Ho than the bigeye croaker (0.009 ± 0.005, Ramsey and Wakeman 1987), whereas other sciaenids show higher values (*M. furnieri* 0.055, Levy et al. 1998; *Sciaenops ocellatus* 0.029 ± 0.017, Ramsey and Wakeman 1987 and 0.047, Bohlmeyer and Gold 1991; *Atractoscion nobilis* 0.044, Bartley and Kent 1990; *Genyonemus lineatus* 0.030, and *Seriphus politus* 0.043, Beckwitt 1983).

The low Ho of the bigeye croacker may be caused by the small number of polymorphic loci detected. Ward et al. (1994) showed that subpopulation heterozygosity was significantly less in freshwater than marine fish, suggesting that marine fish subpopulations have a higher gene flow than freshwater subpopulations or restricted-distribution species. Nevo (1978) and Smith and Fujio (1982) suggested that many factors are involved in the expression of the genetic variability, and some could be related to distribution of the species. Several authors suggest that genetic variability in marine fish will also be influenced by the mobility of each species (Selander and Kaufman 1973), niche variability or divergence in time (Somero and Soulé 1974), effective population size (Fujio and Kato 1979), ecological heterogeneity (Nevo 1978; Smith and Fujio 1982), and environmental variation (Mitton and Lewis 1989). Endemic fishery species like *M. megalops* apparently show a low genetic variability and low average number of alleles per locus because of a complex of factors beyond the natural expression of the species.

Significant deviation from the Hardy-Weinberg equilibrium for all polymorphic loci, the heterogeneity in allele frequencies detected by contingency Chi-square analysis, and the small but significant value of *Fst* suggest a complex population structure despite the small or restricted distribution. Absence of the allele *EST-2*114* from fishing zone 2 and the lack of low mobility alleles from *MDH-1**, *MDH-2**, and *LDH-1** are also indicators of genetic structure. Several authors suggest the absence or reduced level of population structuring in sciaenids (Beckwitt 1983; Ramsey and Wakeman 1987; Ward et al. 1994; Levy et al. 1998), which is inconsistent with our results. This sciaenid characteristic is usually associated with environmental conditions of life history parameters (Levy et al.

1998). However, inbreeding (*Fis* and *Fit*) and population difference indicators are concordant with the deficiency of heterozygotes. The low sample size as a technical consideration would usually explain our results, but a 57 average sample size was higher than suggested for allozyme variability studies (Allendorf and Phelps 1981). Large *Fis* value observed is not related to hermaphroditism or sex reversal, because there is not histological evidence to support it (Castro-Longoria, pers. comm.).

Gorman and Renzi (1979) showed that genetic variability was more affected by the number of loci included in the analysis than the number of specimens involved in the sample. Zymogram misinterpretation was reduced by involving only the loci in which banding pattern was clear and consistent for genetic interpretation. The Wahlund effect would be a side explanation (Maynard Smith 1989), but pooled analysis from both fishing zones show that heterozygote deficiencies were congruent with the deficiencies expressed in the analysis by fishing zone. The average polymorphism of 13% ($P_{0.95}$) was very close to values detected in other studies of sciaenids (Beckwitt 1983; Ramsey and Wakeman 1987) and high levels of variation in polymorphism were observed for those species. No differences in polymorphism from both fishing zones of *M. megalops* reduce the application of this indicator of genetic variability. Ayala and Kiger (1984) mention this characteristic of animal genomes as imprecise and arbitrary.

Apparently enough migrants per generation ($N_em = 9.0$) are not concordant with differences between molecular indicators. On average, Ward et al. (1994) concluded that marine subpopulations exchange 10 to 100 more migrants per generation than restricted distribution species like freshwater subpopulations, presumably because of the relative absence of barriers to dispersal in the marine environment. However, one migrant per generation will be enough to homogenize allelic differences between fishing zones (Slatkin 1987). Natural selection, a fragmented gene pool, and low fish abundance in the reduced occupational distribution appear to be responsible for the genetic structuring of the bigeye croaker in the UGC in the face of genetic flow.

G and *Fst* indicators of differences among fishing zones of *M. megalops* are complementary to evidence of low heterozygosity, low number of alleles per locus, and deviation from Hardy-Weinberg expectations for all polymorphic loci. They form conclusive evidence of genetic variability erosion, and the reduction in population size is now evident through allozyme analysis. The fishing pressure is one of the more determining factors in this decreased genetic variability in this restricted distribution species in the Gulf of California. Effective population size estimations of *M. megalops* in the UGC are nonexistent. Official monthly landing captures of the entire fishery were recovered by SEMARNAP (Ministry of Environment, Natural Resources, and Fisheries, by its initials in Spanish). Capture was 2,346,000 kg in 1997, 4,030,000 kg in 1998, and 5,180,000 kg in 1999 (Portillo-Balderrama and Pedrín-Osuna, pers. comm.). Sampling protocols for this study and subsamples of the specimens from commercial fishery of the bigeye croaker in the UGC report an average weight of 0.5 kg/fish. In a conservative estimation of the level of specimen extraction from the UGC, according the official landing, more than 12 million specimens were taken from 1997–1998, and more than 10 million in 1999. A low-level capture in 2000 was evident, and no restriction measure was made by the federal government because of the lack of precise information of catch per unit effort. Additionally, the volume of illegal catch not included in the official data, and the incidental catch by shrimp trawlers, which was reported as an important volume of catch by several authors in the UGC and in the entire Gulf of California (Pérez-Mellado and Findley 1985; Cudney-Bueno and Turk-Boyer 1998), were not included in the final accounting. The high capture reported results in a reduced population, causing genotypic disequilibrium as a final consequensce (Van-Doornik and Winans 1998).

Another sciaenid, *Totoaba macdonaldi,* an endangered marine fish endemic to the Gulf of California, has been, for a long time, an example of population disequilibrium through fishing pressure (Barrera-Guevara 1990; Lagomarsino 1991). Smith et al. (1991) measured the loss of genetic diversity in the orange roughy, *Hoplostethus atlanticus,* as an integral consequence of heavy exploitation of natural populations. The authors although were not testing the correlation between the heterozygosity and the fish size, their results suggest that fishing activities differentially remove the largest and oldest individuals from virgin stocks and could have a significant influence on the genetic structure of a commercially important species. There are a lack of molecular studies for the bigeye croaker to compare with our data and to measure the impact of the fishery. However, genetic variability and inbreeding indicators from the allozyme study must be a primary tool in the baseline data required to keep a sustainable fishery through appropriate management practices inside and outside of the UGCRBR. Sladek-Nowlis and Roberts (1999), based on fishery population models, show that marine reserves are a viable fishery management alternative. They predict that a reserve will enhance catch from any overfished population that meets the key assumptions that adults did not cross reserve boundaries and that larvae mixed thoroughly across the boundary but were kept sufficient to produce a stock-recruitment relationship for the management area. Little evidence exists of fast recuperation levels in natural overexploited populations after a prolonged decline. However overfishing effects on a single species fishery could be reversible (Hutchings 2000).

Regulations and model assumption applications in the bigeye croaker fishery for the management and population recovery may include a fishing moratorium inside the UGCRBR. Although the social impact associated with prohibition could be disastrous to local fisherman, implementation of a fishery program for the species should permit a level of population recovery adequate to sustain a regulated fishery activity and conservation of the species outside of the UGCRBR. The only alternative to assure *M. megalops* as fishery resource is a well-designed fishery management plan incorporated into the traditional economic activities in the UGCRBR.

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Literature Cited

Abreu-Grobois, A. 1983. Population genetics of *Artemia.* Unpublished PhD Thesis, University College of Swansea, England. 438 Pp.

Aebersold, P.B., G.A. Winans, D.J. Teel, G. Milner, and F.M. Utter. 1987. Manual for starch gel electrophoresis: A method for the detection of genetic variation. NOAA Tech. Rep. NMFS 61: 1–19.

Allen, G.R., and D.R. Robertson. 1994. Peces del Pacífico Oriental Tropical. Smithsonian Tropical Research Institute. Traduction Edition CONABIO, Agrupación Sierra Madre y CEMEX. México, 327 Pp.

Allendorff, F.W., and S.R. Phelps. 1981. Use of allelic frequencies to describe population structure. Can. J. Fish. Aquat. Sci. 38:1507–1514.

Ayala, F.J., D. Hedgecock, G.S. Zummalt, and J.W. Valentine. 1973. Genetic variation in *Tridacna maxima,* an ecological analog of some unsuccessful evolutionary lineages. Evolution 37:177–191.

———, and J.A. Kiger. 1984. Genética moderna. Fondo Educativo Interamericano. México, 836 Pp.

Barrea-Guevara, J.C. 1990. The conservation of *Totoaba macdonaldi* (GILBERT) (Pisces: Sciaenidae), in the Gulf of California, México. J. Fish Biol. 37 Supplement A:201–202.

Bartley, D.M., and D.B. Kent. 1990. Genetic structure of white seabass populations from the Southern California Bight Region: Applications to hatchery enhancement. CalCOFI Rep. 31:97–105.

Beckwitt, R. 1983. Genetic structure of *Genyonemus lineatus, Seriphus politus* (Sciaenidae) and *Paralabrax clathratus* (Serranidae) in Southern California. Copeia 3:691–696.

Bohlmeyer, D.A., and J.R. Gold. 1991. Genetic studies in marine fishes: II: A protein electrophoretic analysis of population structure in the red drum *Sciaenops ocellatus.* Mar. Biol. 108:197–206.

Castro-Aguirre, J.L. 1978. Catálogo sistemático de los peces que penetran a las aguas continentales de México con aspectos zoogeográficos y ecológicos. Dirección General del Instituto Nacional de Pesca. Serie Científica 19:298 Pp.

Chao, N.L. 1995. Sciaenidae: Corvinas, barbiches, bombaches, corvinatas, corvinetas, corvinillas, lambes, pescadillas, roncachos, verrugatos. Pp. 1427–1518. *In*: Guía para la identificación de especies para los fines de la pesca. Pacífico Centro-Oriental. W Fischer, F. Krupp, W. Schneider, C. Sommer, K.E. Carpenter y V.H. Niem (eds.), Vol. III. Vertebrados-Parte 2. Roma FAO. 1201–1813 Pp.

Crawford, M.K., C.B. Grimes, and N.E. Buroker. 1988. Stock identification of weakfish, *Cynoscion regalis,* in the Middle Atlantic Region. Fish. Bull. 87:205–211.

Cudney-Bueno, R., and P.J. Turk-Boyer. 1998. Pescando entre mareas del Alto Golfo de California. Una guía sobre la pesca artesanal, su gente y sus propuestas de manejo. CEDO Intercultural, Serie Técnica, No. 1:1–166 Pp.

Fujio, Y., and Y. Kato. 1979. Genetic variation in fish populations. Bull. Jap. Soc. Sci. Fish. 45:1169–1178.

Gold, J.R., K.M. Kedzie, D.A. Bohlmeyer, J.D. Jenkin, W.J. Karel, N. Iida, and S.M. Carr. 1988. Studies on the basic structure of the red drum (*Sciaenops ocellatus*) genome. Contrib. Mar. Sci. supplement to Vol. 30:57–62.

———, L.R. Richardson, T.L King, and G.C. Matlock. 1993. Temporal stability of nuclear gene (allozyme) and mitochondrial DNA genotypes among red drums from the Gulf of Mexico. Trans. Amer. Fish. Soc. 122:659–668.

———, and L.R. Richardson. 1994. Genetic distinctness of red drum (*Sciaenops ocellatus*) from Mosquito Lagoon, east-central Florida. Fish. Bull. 92:58–66.

Gorman, G.C., and J. Renzi Jr. 1979. Genetic distance and heterozygosity in electrophoretic studies: effects of sample size. Copeia 2:242–249.

Grant, W.S., and F.M. Utter. 1980. Biochemical genetic variation in walleye pollock, *Theragra chalcogramma*: Population structure in the southeastern Bering Sea and the Gulf of Alaska. Can. J. Fish. Aquat. Sci. 37:1093–1100.

———, D.J. Teel, and T. Kobayashi. 1984. Biochemical population genetics of Pacific halibut (*Hip-*

poglossus stenolepis) and comparison with Atlantic halibut (*H. hippoglossus*). Can. J. Fish. Aquat. Sci. 41:1083–1088.

Hartl, D.L. 1988. A primer of population genetics. Sinauer Associates, Inc. Sunderland, Massachusetts, 305 Pp.

Hutchings, J.A. 2000. Collapse of marine fishes. Nature 406:882–885.

IUBNC (International Union of Biochemistry, Nomenclature Committee). 1984. Enzyme Nomenclature 1984. Academic Press. Orlando, Florida, 646 pp.

Lagomarsino, I. 1991. Endangered species status review, *Totoaba macdonaldi*. National Marine Fisheries Service Southwestern Region, Administrative Report SWR-91-01, 9 Pp.

Levy, J.A., Maggioni R., and M.B. Conceicáo. 1998. Close genetic similarity among populations of the white croaker (*Micropogonias furnieri*) in the south and south-eastern Brazilian coast. I. Allozyme studies. Fish. Res. 39:87–94.

Li, C.C., and D.G. Horvitz. 1953. Some methods of estimating the inbreeding coefficients. Amer. J. Human Gen. 5:107–117.

Maynard Smith, J. 1989. Evalutionary genetics. Oxford University Press. Oxford, 325 Pp.

Mitton, J.B., and W.M. Lewis Jr. 1989. Relationships between genetic variability and life-history features of bony fishes. Evolution 43:1712–1723.

Nei, M. 1978. Estimation of average heterozygosity and genetic distance from a small number of individuals. Genetics 98:583–590.

Nevo, E. 1978. Genetic variation in natural populations: Patterns and theory. Theor. Pop. Biol. 13: 121–177.

Pérez-Mellado, J., and L.T. Findley. 1985. Evaluación de la ictiofauna acompañante del camarón comercial en las costas de Sonora y Sinaloa. *In*: 201–253 Pp. Recursos Pesqueros Potenciales de México: La pesca acompañante del camarón. Yánez-Arancibia A. (Ed.), Instituto de Ciencias del Mar y Limnología UNAM, Instituto Nacional de la Pesca, Secretaría de Pesca. México.

Poulik, M.D. 1957. Starch gel electrophoresis in a discontinuous system of buffers. Nature 180:1477–1479.

Raymond, M., and F. Rousset. 1995. GENEPOP (version 1.2): population genetics software for exact tests and ecumenicism. J. Heredity 86:248–249.

Ramsey, P.R., and J.M. Wakeman. 1987. Population structure of *Sciaenops ocellatus* and *Cynoscion nebulosus* (Pisces: Sciaenidae): Biochemical variation, genetic subdivision and dispersal. Copeia 3:682–695.

Rice, W.R. 1989. Analyzing tables of statistical tests. Evolution 43:223–225.

Román-Rodríguez, M.J., J. Figueroa, R. Castro-Longoria, and L.M. Yépiz-Velásquez. 2000. Estudio poblacional del chano norteño, *Micropogonias megalops* y la curvina golfina *Cynoscion othonopterus* (Pieces: Sciaenidae), especies endémicas del Alto Golfo de California, México. Informe Final del Proyecto L298 CONABIO, A.C. Instituto del Medio Ambiente y Desarrollo Sustentable del Estado de Sonora y Departamento de Investigaciones Científicas y Tecnológicas de la Universidad de Sonora, México. 147 Pp.

Rosa-Velez, J. 1986. Variabilidad genética poblacional en ostiones de la especie *Crassostrea virginica* del Golfo de México. Unpublished Doctoral Thesis, UNAM. Mexico. 124 Pp.

Schaal, B.A., and W.W. Anderson. 1974. An outline of techniques for starch gel electrophoresis of enzymes from the American oyster *Crassostrea virginica* Gmelin. Tech. Rep. Ser. Georgia Marine Science Center. (74-3):1–17.

Selander, R.K., and D.W. Kaufman. 1973. Genetic variabilities and strategies of adaptation in animals. Proc. Nat. Acad. Sci. USA 70:1875–1877.

———, M.H. Smith, J.Y. Yang, W.E. Johnson, and J.B. Gentry. 1971. Biochemical polymorphism and systematics in the Genus *Peromyscus* I, Variation in the old field mouse (*Peromyscus polionatus*). Stud. Genet. VI. Univer. Texas Publ., 7103:49–90.

Shaklee, J.B., F.W. Allendorf, D.C. Moritz, and G.S. Whitt. 1990. Gene nomenclature for protein-coding loci in fish. Trans. Amer. Fish. Soc. 119:2–15.

Shaw, C.R., and A.L. Koen. 1968. Starch gel zone electrophoresis of enzymes. *In*: 325–364. Pp. I. Smith (ed.), Chromatographic and Electrophoresis Technics, Interscience.

———, and R. Prasad. 1970. Starch gel electrophoresis of enzymes. A compilation of recipes. Biochem. Gen. 4:297–320.

Sladek-Nowlis, J., and C. M. Roberts. 1999. Fisheries benefits and optimal design of marine reserves. Fish. Bull. 97:604–616.

Slatkin, M. 1987. Gene flow and the geographic structure of natural populations. Science 236:787–792.

Smith, P.J., R.I.C.C. Francis, and M. McVeagh. 1991. Loss of genetic diversity due to fishing pressure. Fish. Res. 10:309–316.

———, and Y. Fujio. 1982. Genetic variation in marine teleosts: High variability in habitat specialists and low variability in habitat generalists. Mar. Biol. 69:7–20.

Somero, G.N., and M. Soulé. 1974. Genetic variation in marine fishes as a test of the niche-variation hypothesis. Nature 249:670–672.

Suzuki, H., A.E.A. de M. Vazzoler, and P. Van-Ngan. 1983. Estudo electroforético de proteínas de músculo esquelético de *Micropogonias furnieri* (Desmarest, 1823) da costa SE-E do Brasil. Bol. Instituto Oceanográfico, Sao Paulo 32:153–165.

Swofford, D., and R. Selander. 1981. BIOSYS-1—A fortran program for the comprehensive analysis of electrophoresis data in population genetics and systematics. J. Heredity 72:281–283.

Van-Doornik, D.M., and G.A. Winans. 1998. Inheritance of allozymes in Coho salmon. Trans. Am. Fish. Soc. 127:833–837.

Wakeman, J.M., and P.L. Ramsey. 1988. Population structure and genetic variation in red drum. Contrib. Mar. Sci., Supplement to vol. 30:49–56.

Ward, R.D., M. Woodwark, and D.O.F. Skibinski. 1994. A comparison of genetic diversity levels in marine, freshwater, and anadromous fishes. J. Fish Biol. 44:213–232.

Weir, B.S. 1996. Genetic data analysis II. Methods for discrete population genetic data. Sinauer Associates, Sunderland, MA.

Workman, P.L., and J.D. Niswander. 1970. Population studies on Southwestern Indian Tribes. II Local genetic differentiation in the Papago. Amer. J. Human Gen. 22:24–29.

Wright, S. 1965. The interpretation of population structure by F-statistics with special regard to systems of mating. Evolution 19:395–420.

Zar, J.H. 1984. Biostatistical analysis. Prentice may. Englewood Cliffs, New Jersey, 718 Pp.

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Influence of Abiotic Factors on the Persistence of Kelp Habitats Along the North Coast of Santa Monica Bay

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Abstract.—The distribution and abundance of kelp forests flanking Santa Monica Bay are spatially and temporally variable and have shown an overall decline in biomass over the past few decades, especially along the northern arm of the bay in Malibu. Our objective was to quantify the within patch abundance of giant kelp *Macrocystis pyrifera* (L.) C. Ag. fringing northern Santa Monica Bay and to measure a suite of physical factors that may influence its local distribution and abundance. For comparison, these factors were also measured for the southern arm of the Bay along the Palos Verdes Peninsula, an area characterized by larger, more persistent kelp forests. Of the measured factors, the amount and stability of suitable substrate and the sediment type appear to have the largest influence on kelp density. The amount of hard substrate available for kelp recruitment and growth is higher along the Palos Verdes peninsula as compared to the Malibu coastline, but both regions' rocky reefs demonstrate temporal shifts in areal extent. Furthermore, sediment size also varies along the two coasts with Malibu sediment consisting of a lower percentage of larger particles which typically are resuspended less than smaller, more mobile particles. These abiotic factors may strongly regulate the size of *Macrocystis pyrifera* populations in the Santa Monica Bay and may help explain the observed difference in kelp abundance between the Bay's two coastlines.

At a local level, the distribution and abundance of giant kelp (*Macrocystis pyrifera*) populations have been found to be primarily affected by abiotic and biotic factors such as light availability, substrate composition, water motion, grazing, and competition (North 1994). Larger-scale changes to kelp coverage can be catalyzed by shifts in temperature and its resulting effect on macronutrient loads (Dayton and Tegner 1984; Hernandez-Carmona et al. 2000). In this study, we began to characterize some of the local factors that potentially contribute to the high variability of kelp populations along the Malibu coastline in the Santa Monica Bay.

A review of historical data from ISP Alginates (Glanz, unpublished data) documented a trend of declining kelp abundance in Malibu (Figure 1a). After approximately 20 years of variable, but relatively high kelp abundance in the 1960s and early 1970s, kelp populations exhibited major declines in 1976 that continued

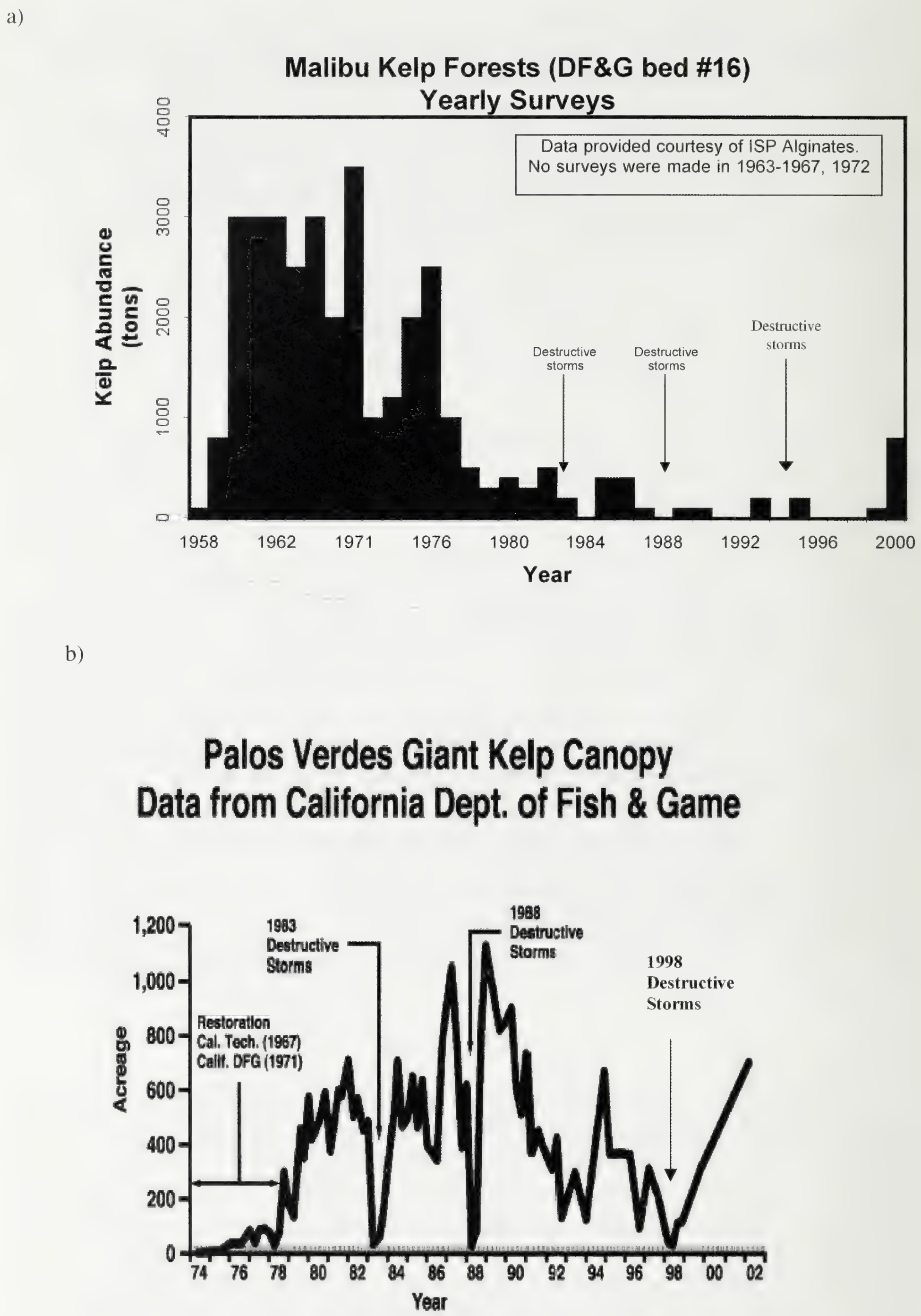


Fig. 1. a) Abundance of the giant kelp *Macrocystis pyrifera* (in tons) in the area designated as bed #16 by the California Department of Fish and Game (from Glanz, unpublished data). Kelp bed #16 is the area from Point Dume to Malibu Point, and thus encompasses all of our Malibu study sites. b) Kelp canopy coverage as reported in the Los Angeles County Sanitation Districts Palos Verdes Ocean Monitoring Report (2001). Acreage data is reported from 1974–2002.

through 2000. In contrast, kelp beds in Palos Verdes (PV), the southern arm of the Bay, did not show such a drastic, long-term decline in kelp abundance (Figure 1b; Los Angeles County Sanitation Districts Palos Verdes Ocean Monitoring Report 2001). Although kelp coverage was variable from year to year, the Palos Verdes kelp beds were generally persistent over the last two decades and quickly rebounded from low biomass years. Although direct comparisons between the two coasts cannot be made due to differences in estimating kelp abundance, long-term kelp bed persistence appears to differ between the two coasts.

Many physical and chemical factors affect the growth and biomass accumulation of kelp forests. Kelp populations are typically associated with cold water, as well as a relatively high light and nutrient environment (North 1994). Large amounts of sediment in the water, either from land or resuspension from the benthos could reduce light, and may negatively impact kelp productivity by reducing growth rates and inflating mortality (Devinny and Volse 1978; Dean et al. 1983; Dean et al. 1989). Regular underwater SCUBA surveys of kelp beds over three years (1999–2001) have shown notable amounts of sediment suspended in the water column (Mohajerani, Pers. Obs.). It has also been observed that the sediment in the Malibu region is very mobile and may be covering the rocky reef surface. The amount (areal extent) and stability (duration of availability) of suitable substrate is likely an important factor affecting kelp densities. Kelp requires hard substrate for recruits to settle and this substrate must remain uncovered by sand in order for kelp to survive, especially through the early juvenile stage (North 1994).

Our objective was to compare the current within patch abundance of kelp thalli in northern and southern Santa Monica Bay and to measure a suite of physical factors that may influence kelp distribution and abundance on the two coasts. We measured several parameters including floral and faunal abundance, sedimentation rates, amount of available substrate, sediment type, levels of pollutants and nutrients in kelp thalli and sediments, and sediment organic matter to determine if they warranted further investigation.

Methods

To determine the abundance of kelp within beds along the northern coast of the Santa Monica Bay, eight rocky reef sites with established kelp beds were chosen along the Malibu coastline from Point Dume to Malibu Point (Figure 2). These sites were established in areas dominated by kelp and known to have historically supported kelp forests. Three comparative sites were selected along the Palos Verdes Peninsula from Malaga Cove to Palos Verdes Point (Figure 2). Permanent buoys were fixed at each field site.

Biological Surveys

Kelp bed sites were surveyed using SCUBA to document the distribution and abundance of kelp thalli as well as associated algal and invertebrate assemblages. These biological surveys were conducted in both fall 2000 and spring 2001. Targeted species were sampled employing both quadrat and band transect field methods. To determine the abundance of adult giant kelp (length $\geq$1 m) and sub-adult giant kelp (length $<$1 m, species identifiable), as well as rare algal and invertebrate species, 1–2 50 m band transects were laid out along a depth contour starting at

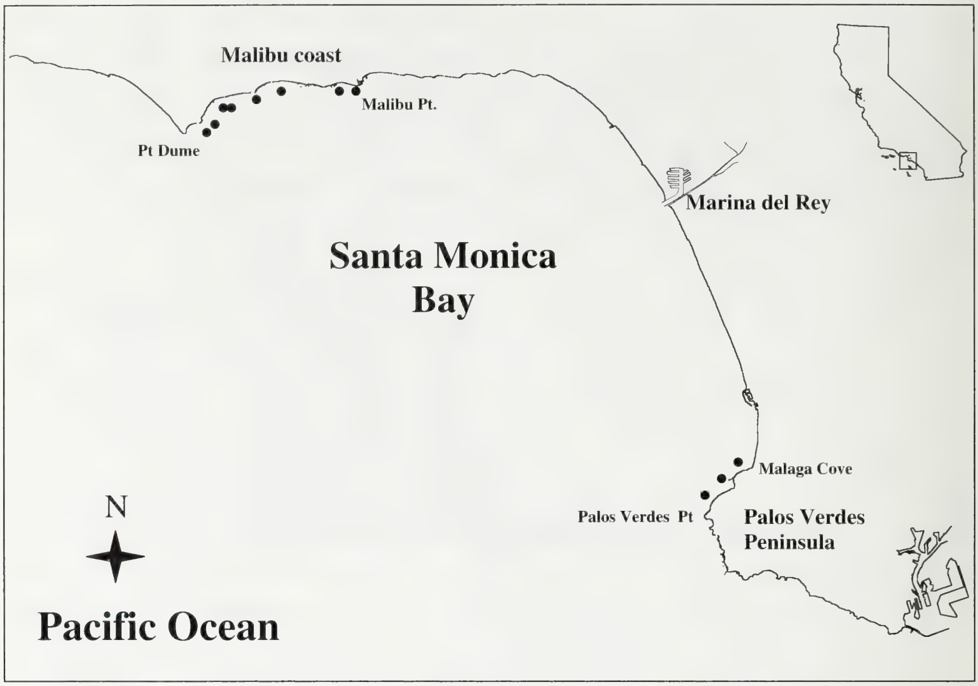


Fig. 2. Map of eight research sites in Malibu and three in Palos Verdes.

each site marker buoy. Sub-adult kelp were distinguished by size (<1 m in height) and not by the number of stipes as used in other studies (eg. Dayton et al. 1992) as we were interested in newly recruited individuals. Divers surveyed the 50 m transect tapes in five (2 m × 10 m) contiguous sections. Although divers searched for species under ledges and in cracks, they did not move or lift rocks. In addition to band transects, juvenile kelp (kelp <1 m but with no basal cleft—kelp species indistinguishable) and more common invertebrate and algal species were sampled within five 2 m × 1 m quadrats placed randomly along each 50 m transect.

Biological survey data were analyzed to detect spatial and temporal trends in kelp bed communities. All biological survey data, as well as all data on physical factors affecting kelp distribution, were tested for homogeneity of variance and transformed when necessary. We employed 2 Way ANOVAs to determine site and seasonal differences (fixed factors). In addition, we used mean values for each site to conduct 2 Way ANOVAs to test differences among regions (Malibu and PV) and season (fixed factors). Only data for the three size classes of kelp (adult, sub-adult, and juvenile) will be presented in this report due to the lack of significant trends apparent in overall biotic community data.

Substrate Availability

We conducted surveys of the physical composition of the benthos along the Malibu and PV coasts in fall 2000 and spring 2001 to determine the availability and height of hard substrate and to assess coverage and depth of soft bottom substrate. Twenty-two sites were randomly chosen along the Malibu coast and 13 along the PV coast for the fall survey; however, replication was reduced to 16

(Malibu) and 6 (PV) for spring surveys. Sites were restricted to the same depth contours that were identified earlier as able to support kelp forests during our site selection process, but were not limited to extant kelp patches. Instead, sites were chosen randomly along the depth contour so that the results could be extrapolated to each coast as a whole.

At each substrate survey site, a 100 m transect tape was laid along the depth contour and the substrate-type recorded at 1 m intervals. If hard bottom was emergent, the category of reef height (≤1 m, >1–2 m, and >2 m) was estimated. If the benthos was covered by sand, a thin metal rod was inserted into the sediment and the substrate depth category was recorded (≤5 cm, >5–10 cm, and >10 cm). Thus, for each site there were 100 observations of benthic substrate type. From these data, percent cover of the six-substrate types was calculated and analyzed using a MANOVA followed by individual 2 Way ANOVAs on untransformed data for each category with region and season as fixed factors.

Sedimentation

Sedimentation is an important factor that may affect water turbidity (and thus light penetration) as well as burial and scouring by sediment particles. Sedimentation rates were measured using a pair of sediment traps deployed at each of the 11 field sites. In order to compare sedimentation rates within the kelp canopy to sediment rates in sandy benthos, traps were deployed at each site within the kelp forest and in adjacent exposed sandy patches. For seasonal comparison, sediment traps were deployed in both summer 2000 and winter 2000. Sediment traps were constructed using 5-inch diameter PVC pipe. The tops of the sediment traps were approximately 30 cm above the substrate and were fitted with 1 cm^2 wire screening to prevent debris from clogging traps while permitting sediment particles to enter. After being deployed in the field for approximately 7 days (bottom time was recorded for each pair of sediment traps and ranged from 144–170.5 hours) collected sediments were dried at 60° C, weighed, and ground using mortar and pestle. Sedimentation rate per hour was calculated for each sample. Due to low sample size, sedimentation rates in PV were excluded from the analyses. Data from Malibu sites were analyzed using a 3 Way ANOVA on sine transformed data with site, season, and habitat (sand plain and kelp forest) as fixed factors.

To examine possible differences in sediment composition between the Palos Verdes and Malibu coasts and among habitat types, we analyzed the grain size of sediment collected from the traps. When suitable amounts of sediment (>30 g dry wt) were collected, grain size was analyzed using the hydrometer method (Bouyoucos 1962) in which sediment particles are divided into three categories of decreasing size: sand, silt, and clay. Data were initially analyzed using a MANOVA on untransformed data with region and habitat as fixed factors and subsequently reanalyzed for each individual category using a 2 Way ANOVA with the same factors.

Sediment, water and/or kelp tissue samples collected at each field site were also analyzed to determine the metal and nutrient content of each. Samples were sent to CRG Marine Laboratories, Inc (Torrance, CA) for metals analyses and to Division of Agriculture and Natural Resources (DANR) Analytical Laboratory at UC Davis for nutrient analyses. No specific trends were observed and these analyses will not be discussed any further.

Any remaining sediment samples were analyzed for their organic matter content (% dry weight). Dried and ground sediment samples were sent to DANR for analyses of organic content. Data were analyzed with a 3 Way ANOVA on log transformed data with region, season, and habitat as fixed factors.

Results

Biological Surveys

There was a significant interaction between site and season on the abundance of adult kelp (Table 1). Interaction occurred because there appeared to be a strong season pattern in PV, but patterns were mixed in Malibu (Figure 3a). Of all the sites, highest abundance occurred at the Pepperdine West site in the fall. When comparing the two regions, Palos Verdes and Malibu, we found no difference in the abundance of adult kelp thalli between the two regions (Table 1), probably due to the high variability in kelp abundance in Malibu in fall (Figure 3b). There was almost a significant seasonal difference with at about twice as many adult kelp thalli in fall compared to spring for both coasts. The interaction term was not found to be significant.

There were significant interactions between site and season on the abundance of sub-adult kelp thalli within band transects (Table 1). The interaction term was found to be significant as the pattern whether fall was higher than the spring varied at some sites (Figure 3c). Patterns were quite different for sub-adults and adults. There were far fewer sub-adults along the PV coast, where we found measurable abundance in only one site in spring, and none in fall. There were many sites along the Malibu coast where sub-adults were not present, especially in fall. Again, kelp abundance was highest in Pepperdine West in fall. Although there were always more sub-adult kelp thalli along the Malibu coast compared to PV (Figure 3d), a 2 Way ANOVA yielded no significant differences among regions, season, or the interaction term (Table 1). This is likely due to the low samples size in PV for fall ($n = 2$).

There were no differences in mean abundance of juvenile kelp measured in 1 m^2 quadrats among sites (Table 1). Juvenile kelp was either low, or high and extremely variable within a site (Figure 3e). There were differences in mean kelp abundance between seasons. Although juvenile kelp fronds were found in more sites in fall, the highest within site abundance was in spring. The interaction term was not found to be significant. There were no differences in mean density of juvenile kelp between regions, seasons, or the interaction term (Table 1). This may be attributed to high variability in juvenile kelp among sites in Malibu in spring even though there was a trend of more juveniles (Figure 3f).

Available Substrate

The benthic structure of Malibu and PV coasts varied significantly (MANOVA, Wilks' Lambda, $p = 0.026$, $F = 2.55$, num. $df = 7$) with Malibu appearing to be covered by more sand than PV. The season and interaction term were not found to be significant (MANOVA, Wilks' Lambda, $p = 0.066, 0.164$, $F = 2.07, 1.58$, num. $df = 7, 7$; respectively).

The percent of the benthos comprised of low relief hard bottom areas (0–1 m emergent above sand plain) varied between the Malibu and PV coasts (Table 1; Figure 4a) and between fall and spring. The interaction term was not found to be

Table 1. Summary of 2 Way ANOVA results with site (11 sites) or region (Malibu v Palos Verdes), season (Winter and Fall), and their interactions as fixed factors. Reported are degrees of freedom (df), F Stat, and the P value for several measurements of kelp abundance and available substrate. 2 Way ANOVA results are also reported for grain size analysis with region (Malibu v Palos Verdes), habitat (sand plain and kelp forest), and their interactions as fixed factors.

		Site/Region			Season			Site/Region × Season	
	df	F	P	df	F	P	df	F	P
Kelp Abundance:									
Adult Kelp Among Sites	10	8.29	<0.001	1	7.00	0.010	6	3.31	0.006
Adult Kelp Among Regions	1	0.61	0.446	1	4.17	0.061	1	0.64	0.429
Sub-adult Kelp Among Sites	10	9.23	<0.001	1	6.37	0.014	6	3.93	0.002
Sub-adult Kelp Among Regions	1	2.93	0.109	1	0.01	0.772	1	0.01	0.913
Juvenile Kelp Among Sites	10	1.06	0.407	1	4.77	0.032	6	1.39	0.230
Juvenile Kelp Among Regions	1	2.75	0.120	1	1.75	0.208	1	3.16	0.097
Available Substrate									
0–1 m emergent rock	1	6.96	0.011	1	14.04	<0.001	1	1.06	0.309
1–2 m emergent rock	1	10.02	0.003	1	1.20	0.279	1	0.52	0.476
>2 m emergent rock	1	3.74	0.058	1	0.08	0.784	1	3.59	0.064
0–5 cm sand depth	1	0.70	0.406	1	0.21	0.152	1	0.26	0.112
5–10 cm sand depth	1	0.76	0.388	1	0.01	0.941	1	3.48	0.068
> 10 cm sand depth	1	4.24	0.045	1	12.02	0.001	1	1.55	0.219
		Region			Habitat			Regtion × Habitat	
	df	F	P	df	F	P	df	F	P
Grain Size									
Sand	1	5.04	0.046	1	0.72	0.413	1	0.04	0.837
Clay	1	3.86	0.075	1	0.40	0.542	1	0.17	0.686
Silt	1	2.51	0.141	1	0.97	0.345	1	0.39	0.544

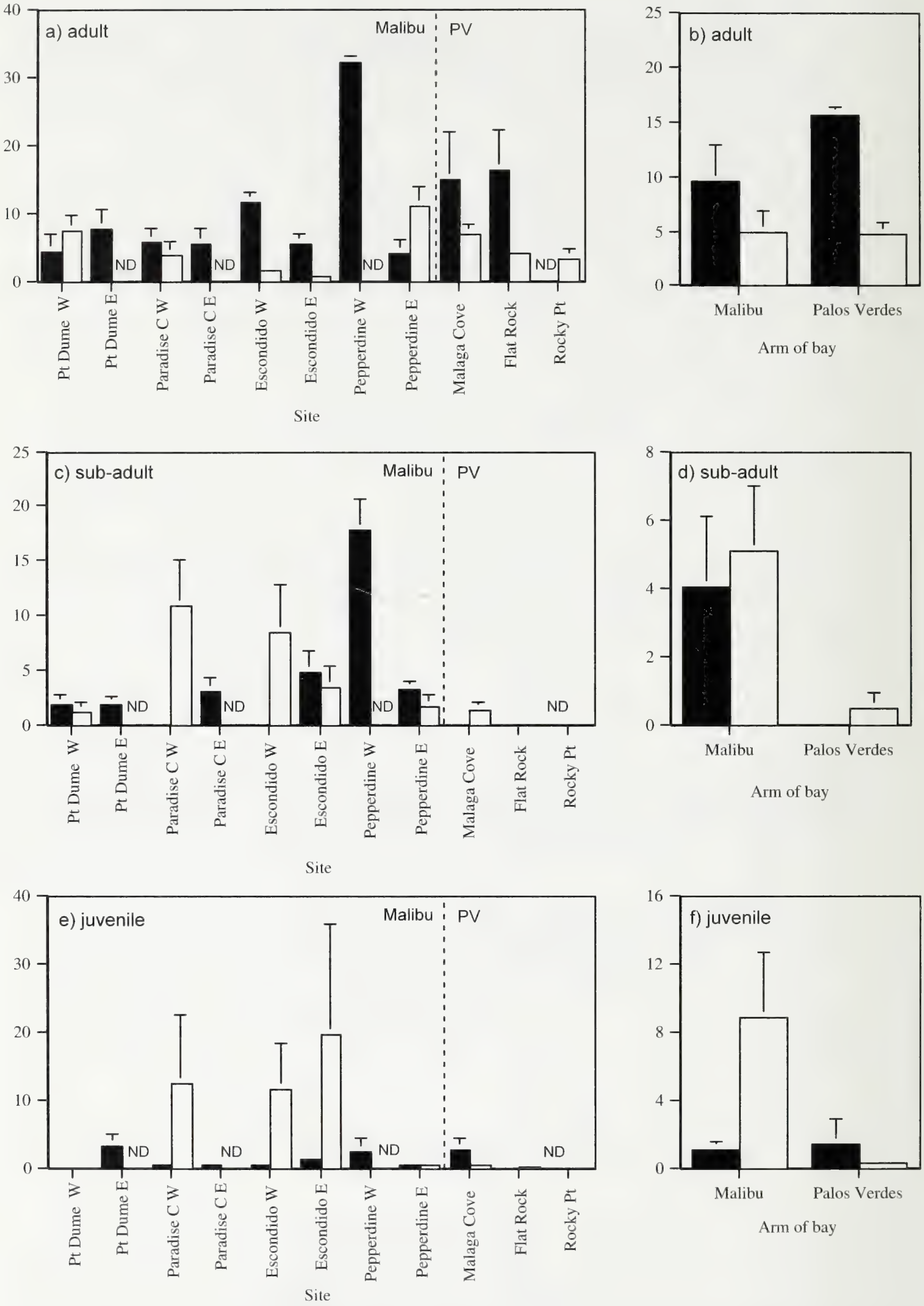
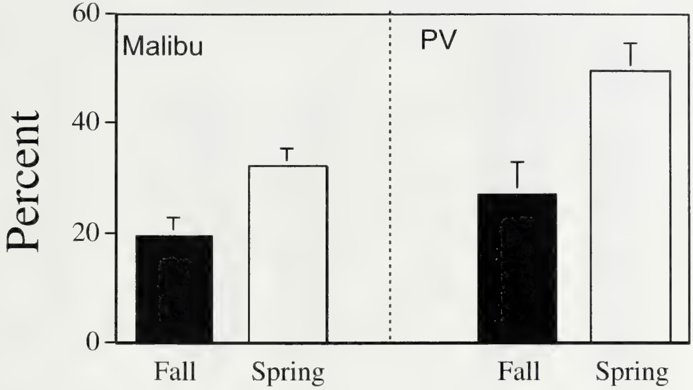
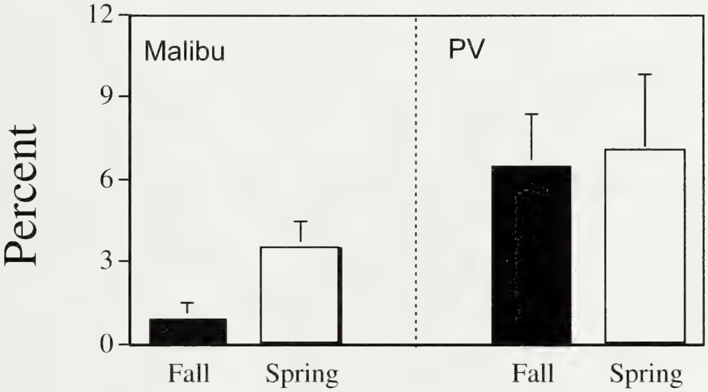


Fig. 3. Mean abundance of kelp of three size classes for each site along the Malibu (Point Dume West to Pepperdine East) and PV (Malaga Cove to Rocky Point) coasts and the mean abundance for each of the two regions (Malibu and PV). Reported are mean abundance (± 1 SE) for fall 2000 (black fill) and spring 2001 (white fill) for adult (≥1 m height, a, b), sub-adult (<1 m maximum height, with basal cleft, c, d), and juvenile (<1 m maximum height, without basal cleft, e, f) kelp thalli. ND = No data collected, no value = 0).

a) Hard substrate 0-1 m



b) Hard substrate 1-2 m



c) Sand depth >10 cm

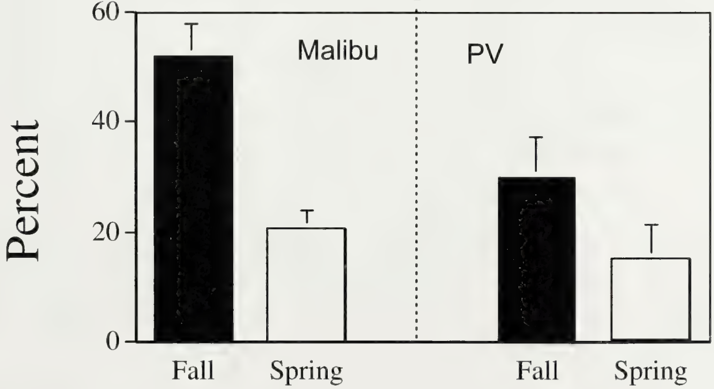


Fig. 4. Mean percent of the benthos (± 1 SE) covered by hard substrate with relief height 0–1 m, relief height 1–2 m, and sand depth >10 cm in Malibu and PV. Values are given for surveys conducted in fall 2000 and spring 2001.

Table 2. Dry wt of suspended sediment (g) trapped in sites along the Malibu and Palos Verdes coasts of Santa Monica Bay. Values are mean (± 1 SE). Samples were collected from either within a kelp forest or in the adjacent sand plain in both winter and summer. If the sample size was too low, the SE was not determined (nd).

Location	Sedimentation rate (dry wt hr^{-1})	Sample size
Malibu		
Summer	0.545 (0.115)	n = 15
Winter	0.750 (0.224)	n = 16
Palos Verdes		
Summer	0.248 (nd)	n = 2
Winter	1.168 (nd)	n = 1

significant. The amount of hard bottom in this category was highest, about 50%, in PV in spring, but decreased to less than 30% in fall. Malibu also had more hard bottom reefs emergent by 0–1 m in spring than fall, 30% versus 20%, respectively. However, the amount of emergent reef in this category was always lower in Malibu than PV.

Higher relief reefs between 1–2 m above the sand plain comprised less of the benthos than the lower reefs, but were more stable through time (Figure 4b). There was significantly greater mean cover of 1–2 m high reefs in PV than Malibu (Table 1), but no difference between seasons or interactions. Reefs in the highest relief category (>2 m) were very rare, so statistical analysis, although reported in Table 1, will not be discussed. In general, there was more reef in this category found in PV (fall 3.8 ± 1.5, spring 1.6 ± 1.0) than Malibu (fall 0.0 ± 0.0, spring 1.6 ± 1.0).

In contrast to hard substrate, the amount of benthos covered by deep sand (>10 cm depth) was higher in Malibu than PV (Table 1; Figure 4c) and greater in fall than spring with no significant interactions. Benthos covered by sand in the ≤5 cm, and >5–10 cm categories were not found to be significant for either factor or the interaction term (Table 1).

Sedimentation

During both summer and winter, several of the sediment traps were lost or tipped over onto their sides resulting in low sample sizes, especially for PV. Sedimentation rates appeared to be higher in Malibu than PV in the summer (Table 2) but were difficult to statistically analyze due to lack of replication. A One Way ANOVA showed that Malibu and PV were statistically similar ($p = 0.847$, $F = 0.04$, $df = 1$) but the power of the analysis was very low (0.054). Within Malibu sites only, sedimentation rates did not vary significantly among sites, season, habitat, or any of the interaction terms (3-Factor ANOVA, $p > 0.05$ for all factors).

Sediment type was found to be dominated by sand, the largest grain size category analyzed. Sand made up over 75% of all sediment samples. A MANOVA yielded no significant differences among sediment makeup between Malibu and PV ($p = 0.194$, $F = 1.94$, Num $df = 3$), habitat ($p = 0.785$, $F = 0.36$, Num $df = 3$), or their interactions ($p = 0.581$, $F = 0.69$, Num $df = 3$). This may be attributed to two of the three sediment types not being significant when individual

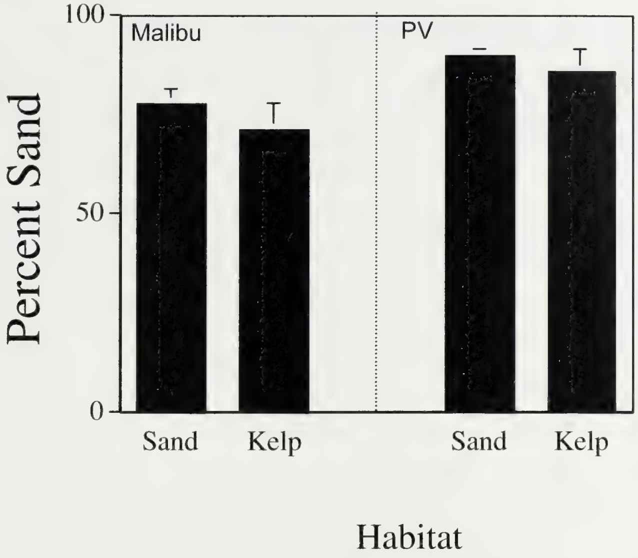


Fig. 5. Mean percentage (± 1 SE) of sediment consisting of sand, the largest of three measured grain size categories, from within kelp beds and adjacent sand plain habitats in Malibu and PV.

2 Way ANOVAs were conducted. Both clay and silt percentages were not found to be significantly different between PV and Malibu (Table 1), although there was a trend of higher clay and silt in Malibu. However, there was a significant difference in the percentage of sediment consisting of sand between PV and Malibu (Table 1) with PV having more sand than Malibu (Figure 5). The habitat that the sediment was collected in (sand plain and kelp forest) was not found to be significantly different nor was the interaction term for any of the three sediment types.

The organic matter content of sediment was found to be higher in Malibu than PV in both the kelp and sand habitat (Table 3), suggesting that there was more deposition of material from either terrestrial or marine origin in this region. There was a significant difference among Malibu and PV (3-Factor ANOVA, $p = 0.017$, $F = 6.27$, $df = 1$) but organic matter content did not vary among habitat, season, or any of the interactions (3-Factor ANOVA, $p > 0.05$ for all).

Table 3. Sediment organic matter content (% dry wt) in sites along the Malibu and Palos Verdes coasts of Santa Monica Bay. Values are mean (± 1 SE). Samples were collected from either within a kelp forest or in the adjacent sand plain. Samples were collected in both winter and summer, but there were no statistical differences between seasons, so season was dropped from the analysis.

Location	Organic Matter (% dry wt)
Malibu	
Kelp	2.886 (0.402)
Sand	1.931 (0.245)
Palos Verdes	
Kelp	1.520 (0.319)
Sand	1.004 (0.167)

Discussion and Recommendations

The results of our study suggest substrate areal extent and stability should be investigated further to determine their importance in driving patterns of abundance and distribution in kelp along the northern arm of the Santa Monica Bay. In general, our study has shown that there is more area of sand, and sand patches are deeper in Malibu while there is more high relief, hard-bottom in PV. In addition, the availability of hard substrate shifts in areal extent more in Malibu compared to PV. This may have important repercussions on the survival and recruitment of kelp populations along the Bay's northern coast. Currently, the Santa Monica Bay Restoration Project (SMBRP) and CSU Monterey are conducting further investigations into substrate availability along the Malibu coastline employing side scan sonar technology.

The mobility of benthic substrate is a function of the sediment's grain size. Our results suggest that PV sediment is comprised mostly of coarse sand as opposed to Malibu sites where more sediment is of finer particle size. Smaller sized grains are more easily transported along the benthos and can result in the burial and scouring of new kelp recruits. In addition, smaller sized grains are easily resuspended into the water column and may result in less light reaching bottom depths. These factors may have important negative influences on the health and survival of kelp populations in Malibu.

Resuspension of sediments is probably the most important factor reducing water clarity. Although we were unable to detect differences in sedimentation rates between coasts with our data, we think this is also a worthwhile avenue for future investigation. Because there were such dramatic visual differences in suspended sediment both temporally and spatially, it is likely that our low replication and technical difficulties were responsible for the lack of statistical significance. With improved, more sophisticated sediment traps, additional estimates of substrate mobility, including temporal measures of sedimentation rates, would help to clarify these relationships. It is also important to investigate the sources of sedimentation, particularly whether burial and particulates in the water column are a result of the resuspension of marine sediments or sediment loading from terrestrial sources. Terrestrial sediment loading could possibly be an important factor affecting kelp distribution especially in Malibu where watershed connections are numerous.

We had expected that kelp thalli would be denser in PV than Malibu, due to historical evidence and recent aerial photographs. While our results do not support this, we think this lack of support may be attributed, in part, to our method of site selection. We chose sites within established kelp forests, with a known history of supporting kelp. Thus, we cannot determine if PV supports more area of kelp, just that within a kelp forest, population density of adults is similar between coasts. In addition, although the abundance of adult kelp measured as number of individuals within kelp patches did not vary between two coasts, the overall canopy coverage of those patches may be dramatically different due to variance among size of thalli.

We recommend focusing future research on the canopy extent of kelp forests, as well as within patch density. This is important because both patch size and density of kelp beds can significantly contribute to the stability of kelp populations and their persistence over time and space. Studies have shown that a larger forest may be able to recolonize itself more quickly than small, isolated populations (Graham 2003). Large standing stocks not only sustain the parent kelp population, but also increase the range of dispersal to adjacent reefs (Anderson and North 1966). Furthermore, minimum densities of kelp are required to offset grazing pressure by macroinvertebrates and herbivorous fish.

Investigations of kelp demography, especially differences in the size-structure of kelp populations among sites and coasts, are also important. In our study, we classified all thalli ≥1 meter as "adult", and did not differentiate them according to finer scale height categories, biomass, or presence of canopy (length of thallus floating prostrate on the surface). These factors could play a dramatic role in the persistence of kelp populations both temporally and spatially. In healthy *Macrocystis pyrifera* populations, the canopy alone can contain at least half of the total biomass of an individual plant (North et al. 1982) and may produce over 90% of the photosynthate (Towle and Pearse 1973). Increased biomass in kelp plants also leads to increased intensity (Reed 1987) and frequency (Graham 2002) in spore production. Although canopy coverage was not quantified in our study, the Palos Verdes kelp canopy generally was more extensive and denser throughout the study period (Smith, Pers. Obs). Therefore, although our study suggests that the quantity of adult plants is similar between the two coastline kelp beds, the physical characteristics of the individual adult plants may be quite different and may directly contribute to the stability of the entire population. We recommend that future studies include more estimates of kelp population size-structure.

Our data on the abundance of juvenile and sub-adult kelp on Malibu reefs suggests that these populations are not recruitment limited. It is likely that the lower abundance of individuals of smaller size classes (juvenile and sub-adult) at the Palos Verdes sites is related to the observed dense canopy structure as dense canopies can limit the recruitment of new juvenile plants (Reed and Foster 1984; Graham et al. 1997). Future research should focus on the fate of juvenile and sub-adult kelp individuals in kelp patches along both coasts. Clearly recruitment and survivorship to the 1 m stage were greater in Malibu than PV during our sampling period. Therefore, the fate of the smallest adults needs to be investigated. Tagging individual kelp recruits and observing growth and survivorship over time will aid in the understanding of the fate of juveniles, sub-adult, and adult kelp.

We found several seasonal differences in kelp abundances, as expected. Adult kelp abundances were highest in the fall while sub-adult and juvenile kelp abundances were higher in the spring. Seasonal differences in density of adults may be attributed to removal of adults in winter storms and growth with little removal during calmer seas in summer. Our results for sub-adult and juvenile abundances support other research that has shown kelp recruitment to be highest during the spring months when low temperatures and high nutrients optimize algal growth (Dean 1980; Hernandez-Carmona et al. 2000). In addition, high abundances in spring may also be attributed to the higher light availability caused by both increased solar radiation and a thinned kelp forest canopy.

Acknowledgments

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Literature Cited

Anderson, E.K. and W.J. North. 1966. *In situ* studies of spore production and dispersal in the giant kelp, *Macrocystis pyrifera*. Pp. 73–86 *in* Proceedings of the Fifth International Seaweed Symposium (E.G. Young & J.L. McLachlan, eds.), Pergammon Press, New York.

Bouyoucos, G.J. 1962. Hydrometer method improved for making particle size analyses of soils. Agron. J., 54:464–465

Dayton, P.K. and M.J. Tegner. 1984. Catastrophic storms, El Niño, and patch stability in a southern California kelp community. Science, 224:283–285.

———, M.J. Tegner, P.E. Parnell, and P.B. Edwards. 1992. Temporal and spatial patterns of disturbance and recovery in a kelp forest community. Ecol. Monogr., 62:421–445.

Dean, T.A. 1980. Annual report of the kelp ecology project: January 1979 through January 1980. Submitted to the Marine Review Committee, Encinitas, CA 280p.

———, L. Deysher, K. Thies, S. Lagos, F. Jacobsen, and L. Bost. 1983. The effects of the San Onofre Nuclear Generating Station (SONGS) on the giant kelp *Macrocystis pyrifera*: final preoperational monitoring report. Marine Review Committee, Inc., Encinitas, CA.

———, K. Thies, and S.L. Lagos. 1989. Survival of juvenile giant kelp: the effects of demographic factors, competitors, and grazers. Ecology, 70:483–495.

Devinny, J.S. and L.A. Volse. 1978. Effects of sediments on the development of *Macrocystis pyrifera* gametophytes. Mar. Bio., 48:343–348.

Glanz, D. 2001. ISP Alginates' kelp coverage surveys. Unpublished.

Graham, M.H. 2002. Prolonged reproductive consequences of short-term biomass loss in seaweeds. Mar. Bio., 140:901–911.

———. 2003. Coupling propagule output to supply at the edge and interior of a giant kelp forest. Ecology. 84:1250–1264.

———, C. Harrold, S. Lisin, K. Light, J.M. Watanabe, and M.S. Foster. 1997. Population dynamics of giant kelp *Macrocystis pyrifera* along a wave exposure gradient. Mar. Ecol. Prog. Ser., 148: 269–279.

Hernandez-Carmona, G., O. Garcia, D. Robledo, and M. Foster. 2000. Restoration techniques for *Macrocystis pyrifera* (Phaeophyceae) populations at the southern limit of their distribution in Mexico. Botanica Marina, 43:273–284.

Los Angeles County Sanitation Districts. 2001. Ocean Monitoring Annual Report, Chapter 5: Rocky Subtidal.

North, W.J. 1994. Review of *Macrocystis* biology. Pp. 447–527 *in* Biology of Economic algae (I. Akatsuka ed.), SPB Academic Publishing, The Hague, The Netherlands.

———, V.A. Gerard, and J. Kuwabara. 1982. Farming *Macrocystis* at coastal and oceanic sites. Pp. 247–262 *in* Synthetic and Degradative Processes in Marine Macrophytes (L. Srivastava, ed.), De Gruyter, New York.

Reed, D.C. 1987. Factors affecting the production of sporophylls in the giant kelp, *Macrocystis pyrifera*. J. Exp. Mar. Biol. Ecol., 113:61–69.

——— and M.S. Foster. 1984. The effects of canopy shading on algal recruitment and growth in a giant kelp forest. Ecology, 65:937–948.

Towle, D.W. and J.S. Pearse. 1973. Production of the giant kelp, *Macrocystis,* estimated by *in situ* incorporation of ^{14}C in polyethylene bags. Limnol. Oceanogr., 18:155–159.

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RESEARCH NOTES

The Status of *Benthesicymus laciniatus* Rathbun (Decapoda, Penaeoidea, Benthesicymidae) in the Northeastern Pacific

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Species of the shrimp family Benthesicymidae live in the deep sea, usually at 500 m or more. In the northeastern Pacific, the family is represented by species of three genera: *Bentheogennema, Benthesicymus,* and *Gennadas.* The only benthic species of this family belong to the genus *Benthesicymus.* Two species, *B. altus* Bate, 1881 and *B. tanneri* Faxon, 1893 have been reported in the area (Hendrickx 1996).

Schmitt (1921) described *Gennadas pectinatus* from a single female taken off Santa Catalina Island, California. Hayashi (1983, 1992) synonymized *G. pectinatus* with *Benthesicymus laciniatus* Rathbun, 1906, described from a single female taken off Hawaii; and added records from off Japan. The species was listed as *Benthesicymus pectinatus* by Williams et al. (1989), but no explanation was given for the change of name. Farfante and Kensley (1997) reported the range of *B. laciniatus* to include "southern California" as well as the Azores, Canary Islands, Madagascar, Reunion, Saya de Malha Bank, Japan and Hawaii. However, they also listed *G. pectinatus* as a separate species from "off Santa Catalina Island, California."

While sorting specimens in the collections of Scripps Institution of Oceanography (SIO), I found a specimen corresponding to the description of *G. pectinatus.* The specimen was a female, carapace length (cl) 23.3 mm, taken by a 25-foot otter trawl on an abyssal plain off Baja California, Mexico (31°20′N, 120°8′W), 3707–3806 m, 23 March 1970, R/V *Melville,* SIO sta. 3202, SIO cat. no. C3202. I compared the SIO specimen with the holotype of *B. laciniatus* Rathbun, 1906 (female, cl 42.6; vicinity of Kaui Island, Hawaiian Islands [22°03′20″N, 159° 16′15″W], 1471–1325 m, date not recorded, *Albatross* sta. 4018, U.S. National Museum [USNM] cat. no. 30540) and the holotype of *G. pectinatus* (female, cl 35.4; off Santa Catalina Island, California [33°02′15″N, 120°42′W], 2498–3393 m [label on specimen says "2182 fathoms"], 28 March 1904, *Albatross* station 4390, USNM cat. no. 53325). I am satisfied that these three specimens belong to the same species, which should be called *Benthesicymus laciniatus.* The morphology of the SIO specimen agrees well with these specimens and the descriptions and illustrations given by Schmitt (1921) and Hayashi (1983). The rostrum of the SIO specimen has only one, not two, dorsal teeth. Schmitt's illustration and description of the thelycum show a narrow, pointed process on the sixth thoracic sternite. The SIO specimen has a similar pointed process. In the illustration by Hayashi, the process is rounded. All specimens have an oval flap on the seventh thoracic sternite. A faint rectangular area is located on the eighth thoracic somite. No habitat data other than depth were given with the specimens I examined. The SIO specimen was taken in a benthic trawl, as were the two specimens taken by the *Albatross.*

Three species of *Benthesicymus* are known from the northeastern Pacific. Of these, *B. laciniatus* is the only one having spinules along the posterior margin of the fourth abdominal somite. The other two species, *B. tanneri* and *B. altus,* can be distinguished by examination of the fifth and sixth abdominal somites. In *B. tanneri,* the fifth and sixth abdominal somites each end in a small posterodorsal tooth; in *B. altus,* the fifth and sixth abdominal somites do not have teeth but the posterior margin of the sixth somite is raised into a ridge.

Acknowledgments

I thank Larry Lovell (SIO) for allowing me to examine specimens in the collections.

Literature Cited

Bate, C.S. 1881. On the Penaeidea. Ann. Mag. Nat. Hist., (5) 8: 169–196.

Farfante, I., and B. Kensley. 1997. Penaeoid and sergestoid shrimps and prawns of the world. Mém. Mus. Nat. Hist. Nat. Paris, 175: 1–233.

Faxon, W. 1893. Reports on an exploration off the west coasts of Mexico, central and South America, and off the Galapagos Islands, in charge of Alexander Agassiz, by the U.S. Fish Commission steamer "Albatross" during 1891, Lieut. Commander Z.L. Tanner, U.S.N., commanding. 15. The stalk-eyed Crustacea. Mem. Mus. Comp. Zool. Harvard Univ., 18: 1–292.

Hayashi, K. 1983. Prawns, shrimps and lobsters from Japan—14. Family Aristeidae (Benthesicyminae)—Genus *Benthesicymus.* Aquabiology, 5(6): 438–441.

———. 1992. Dendrobranchiata crustaceans from Japanese waters. Tokyo: Seibutsu Kenkyusha. 300 pp.

Hendrickx, M.E. 1996. Los camarones Penaeoidea bentónicos (Crustacea: Decapoda: Dendrobranchiata) del Pacífico Mexicano. Comision Nacional para el Conocimiento y Uso de la Biodiversidad and Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, México, D.F. 147 pp.

Rathbun, M.J. 1906. The Brachyura and Macrura of the Hawaiian Islands. Bull. U.S. Fish Comm. 23, for 1903, part 3: 827–930.

Schmitt, W.L. 1921. The marine decapod Crustacea of California. Univ. Calif. Publ. Zool., 23: 1–470.

Williams, A.B., L.G. Abele, D.L. Felder, H.H. Hobbs, Jr., R.B. Manning, P.A. McLaughlin and I. Pérez-Farfante. 1989. Common and scientific names of aquatic invertebrates from the United States and Canada: decapod crustaceans. Amer. Fish. Soc. Spec. Publ., 17: 1–77.

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INSTRUCTIONS FOR AUTHORS

The BULLETIN is published three times each year (April, August, and December) and includes articles in English in any field of science with **an emphasis on the southern California area**. Manuscripts submitted for publication should contain results of original research, embrace sound principles of scientific investigation, and present data in a clear and concise manner. The current AIBS *Style Manual for Biological Journals* is recommended as a guide for contributors. Consult also recent issues of the BULLETIN.

MANUSCRIPT PREPARATION

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An abstract summarizing in concise terms the methods, findings, and implications discussed in the paper *must* accompany a *feature article. Abstract should not exceed 100 words.*

A feature article comprises approximately five to thirty typewritten pages. Papers should usually be divided into the following sections: abstract, introduction, methods, results, discussion and conclusions, acknowledgments, literature cited, tables, figure legend page, and figures. Avoid using more than two levels of subheadings.

A research note is usually one to six typewritten pages and rarely utilizes subheadings. Consult a recent issue of the BULLETIN for the format of *notes.* Abstracts are not used for notes.

Abbreviations: Use of abbreviations and symbols can be determined by inspection of a recent issue of the BULLETIN. **Omit periods after standard abbreviations:** 1.2 mm, 2 km, 30 cm, but Figs. 1–2. Use numerals *before* units of measurements: 5 ml, but nine spines (10 or numbers above, such as 13 spines). The metric system of weights and measurements should be used wherever possible.

Taxonomic procedures: Authors are advised to adhere to the taxonomic procedures as outlined in the International Code of Botanical Nomenclature (Lawjouw et al. 1956), the International Code of Nomenclature of Bacteria and Viruses (Buchanan et al. 1958), and the International Code of Zoological Nomenclature (Ride et al. 1985). Special attention should be given to the description of new taxa, designation of holotype, etc. Reference to new taxa in titles and abstracts should be avoided.

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McWilliams, K. L. 1970. Insect mimicry. Academic Press, vii + 326 pp.

Holmes, T. Jr., and S. Speak. 1971. Reproductive biology of *Myotis lucifugus.* J. Mamm., 54:452–458.

Brattstrom, B. H. 1969. The Condor in California. Pp. 369–382 *in* Vertebrates of California. (S. E. Payne, ed.), Univ. California Press, xii + 635 pp.

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Volume 103 **Supplement to Number 2**

ABSTRACTS OF PAPERS

2004 Annual Meeting
California State University
Long Beach, California

May 14–15, 2004

BCAS-A103(2, supplement 1–72) (2004) **AUGUST 2004**

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2005 – Loyola Marymount University
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Acknowledgements

The Southern California Academy of Sciences wishes to acknowledge the following organizations and people for their support of the 2004 Annual Meeting.

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Research Training Program

Abstracts 119 to 145 represent the final product of the high school Research Training Program for 2003-04.

The following students were selected to receive an honorary membership in the American Association for the Advancement of Sciences: Joon Bok Lee, Jasmin Hu, Robin Zhou, and Swati Yamanadala.

Based on their oral presentation and research paper, the following students were invited to present their work at the American Junior Association of Science meeting, held in conjuction with the A.A.A.S. meeting in February, 2005 in Washington, D.C.: Joon Bok (James) Lee, Jasmin Hu, Su Fe Ong, Genevieve Williams, Swati Yamanadala, John Young, and Robin Zhou.

We would like to acknowledge the Harbor Association of Industry and Commerce for generously supporting our Research Training Program.

STUDENT AWARD WINNERS AT THE 2004 ANNUAL MEETING

At the 2004 Annual Meeting, the following student papers and posters won awards.

Awarded by the Southern California Academy of Sciences

Best Paper, Physical Sciences

SS Huber, DF Hoyt, DJ Dutto, SJ Wickler. Departments of Biological Sciences, Kinesiology & Health Promotion, and Animal & Veterinary Science California State Polytechnic University, Pomona, CA, 91768

JOINT DYNAMICS OF THE EQUINE FORELIMB DURING JUMPING

Best Papers, Ecology/Evolution

I.C. Phillipsen and A.E. Metcalf. Department of Biology, California State University, 5500 University Parkway, San Bernardino, CA 92407

MOLECULAR ECOLOGY OF A RIPARIAN AMPHIBIAN IN SOUTHERN CALIFORNIA: THE CALIFORNIA TREEFROG (*PSEUDACRIS CADAVERINA*)

C.K. Ellison and R.S. Burton. Marine Biology Research Division, Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA 92037-0208

APPLICATION OF BEAD ARRAY TECHNOLOGY TO COMMUNITY DYNAMICS OF MARINE PHYTOPLANKTON

Best Poster, Ecology/Evolution

R Sison, N. R. Moradian, E. Cole and S. E. Walker. Department of Biological Science, California State University, Fullerton, Fullerton, CA 92834-6850

MALE MORPHOLOGY AND CALLING SONG CHARACTERSTICS IN THE IELD CRICKET, *GRYLLUS BIMACULATUS*

Best Poster, Molecular Biology

Thomas H. Hatch and Christine Broussard. University of La Verne, Department of Biology, La Verne, CA, 91750

THE EFFECTS OF EXCESS ZINC ON DEVELOPING MURINE THYMOCYTES.

Best Poster, Physical Science

*__E. Abeja__, *P.C. Ramirez, *M. Banda, **H. Hernandez, *G. Noriega. *California State University Los Angeles, Department of Geological Sciences, Los Angeles, CA, 90032. **University of Southern California, Department of Earth Sciences, Los Angeles, CA 90089

A PETROGRAPHIC ANALYSIS OF A PALEOSOL IN THE LAS VIRGENES SANDSTONE, SANTA MONICA MOUNTAINS

Awarded by the American Institute of Fishery Research Biologists

Best Fishery Biology Paper Award

Ms. Kimberly Johnson, California State University, Long Beach, Department of Biological Sciences, Long Beach, CA, 90815

STANDARD AND ROUTINE METABOLISM OF KELP BASS *PARALABRAX CLATHRATUS*

Runner up, Best Paper Award

Mr Jesus Reyes, K. Sak[1], M.M. Galima[1], J.L Armstrong[2], and K.M. Kelley[1]. [1]Endocrine Laboratory & Marine Biology Program, Dept. Biological Sciences, California State University, Long Beach, Long Beach, CA 90840; [2]Orange County Sanitation District, Fountain Valley, CA, 92708

ALTERED ENDOCRINE PHYSIOLOGY OF SOUTHERN CALIFORNIA FLATFISH COLLECTED NEAR WASTEWATER TREATMENT PLANT (WWTP) OUTFLOW–STRESS AND GROWTH

Friday, May 14, 2004
Location: Union Ballroom B

Session: Marine Invertebrate Ecology and Marine Pollution Studies: Honoring the Legacy of Donald J. Reish

Chair: John Dorsey, Loyola Marymount University

1. 8:20 **DON REISH'S ANNUAL MARINE POLLUTION LITERATURE REVIEW: FOUR DECADES OF MONITORING THE SCIENCE.** **A.J. Mearns.** Hazardous Materials Response Division, National Oceanic and Atmospheric Administration, Seattle, WA 98115, and P. N. Oshida, U.S. Environmental Protection Agency, Washington, D.C.

2. 8:40 **VARIABILITY IN POLYCHAETES: REGENERATING RUBBER-BANDS?** **K. Fauchald.** Smithsonian Institution, National Museum of Natural History, Department of Zoology, MRC 0163 Washington DC, 20013-7012.

3. 9:00 **RAPID RECOLONIZATION OF INFAUNAL BENTHOS AT A DEEP-SEA DISPOSAL SITE.** **James A. Blake.** ENSR Marine & Coastal Center, 89 Water Street, Woods Hole, MA 02543.

4. 9:20 **SOFT-BOTTOM MEGABENTHIC INVERTEBRATE POPULATIONS AND ASSEMBLAGES OF THE SOUTHERN CALIFORNIA SHELF IN 1998.** **M. James Allen**[1], Doug Diener[2], Erica T. Jarvis[1], Valerie Raco-Rands[1], Christina Thomas[3], Yvette Ralph[3], and Don Cadien.[4] [1]Southern California Coastal Water Research Project, Westminster, CA 92683; [2]MEC Analytical Systems, Inc., Carlsbad, CA 92008; [3]Orange County Sanitation District, Fountain Valley, CA 92728; [4]County Sanitation Districts of Los Angeles County, Whittier, CA 90601.

6. 9:40 **ASSESSMENT OF COPPER EMISSIONS FROM RECREATIONAL VESSEL ANTIFOULING PAINTS IN SOUTHERN CALIFORNIA.** **Kenneth Schiff**, Dario Diehl. Southern California Coastal Water Research Project, Westminster, CA 92683; Aldis Valkirs, Computer Sciences Corp., San Diego, CA 92110.

146. 10:00 **PROBLEMS WITH *PISTA* IN THE NORTHEAST PACIFIC** (**ANNELIDA: POLYCHAETA: TEREBELLIDAE).** **L.H. Harris.** Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007.

7. 10:20 **DISCUSSION OF MALDANID NEPHRIDIA, AND AN EMENDED DESCRIPTION OF THE GENUS *PETALOCLYMENE*** (**ANNELIDA: POLYCHAETA).** **K.D. Green.** MEC Analytical Systems, Inc.–Weston Solutions, Inc., 2433 Impala Drive, Carlsbad, CA 92008.

10:40–11:00 **BREAK**

11:00–11:30 **Welcome, Student Grant Awards, Wheeler J. North Award.**

11:30–12:30 **Plenary Talk: IMPORTANCE OF POLYCHAETES Donald Reish, CSU Long Beach.**

12:30–1:40 **LUNCH BREAK**

Session: Marine Invertebrate Ecology and Marine Pollution Studies: Honoring the Legacy of Donald J. Reish

Chair: Alan Mearns, NOAA

8. 1:40 **BENTHIC POLYCHAETE COMMUNITIES AT THE MOUTH OF THE SAN FRANCISCO BAY.** **Dorothy Norris** and Michael G. Kellogg. City and County of San Francisco, Public Utilities Commission.

9. 2:00 **USE OF REGIONAL DATA TO EVALUATE AND DEVELOP SEDIMENT QUALITY GUIDELINES.** **S.M. Bay**[1], D.E. Vidal[1], and P.L. Myre[2]. [1]Southern California Coastal Water Research Project, Westminster, CA, 92683; [2]Exa Data and Mapping Services, Port Townsend, WA, 98368.

10. 2:20 **DEVELOPING A WATER EFFECTS RATIO FOR AMMONIA IN FRESHWATERS OF LOS ANGELES.** **Jack Q. Word**[1], David W. Moore[1], Ashli Cooper[2], and Mary Ann Irwin[1]. [1]MEC Analytical Systems, Inc.; [2]Larry Walker Associates.

11. 2:40 **LIFE HISTORY CHARACTERISTICS OF *TEREDO NAVALIS* AND *TEREDO BARTSCHI* IN THE VICINITY OF A WARM WATER DISCHARGE: A CASE FOR MONITORING GLOBAL WARMING THROUGH CHANGES IN GEOGRAPHICAL RANGES OF MARINE SPECIES.** **D.E. Morgan.** Millstone Environmental Laboratory, Dominion Nuclear Connecticut, Inc., Waterford Connecticut 06385, USA.

3:00–3:20 **BREAK**

12. 3:20 **THE ANTHOZOAN FAUNA OF OIL PLATFORMS NEAR POINT CONCEPTION, CALIFORNIA.** **John C. Ljubenkov.** Dancing Coyote Ranch, P.O. Box 781, Pauma Valley, CA 92061.

13. 3:40 **DEVELOPMENT OF AN EPIBENTHIC COMMUNITY (ANNELIDA: POLYCHAETA) IN AN ARTIFICIAL SUBSTRATUM AT VERACRUZ REEF SYSTEM, GULF OF MEXICO–AN EXPERIMENTAL APPROACH.** **V. Díaz-Castañeda** (1) & de León-González, J.A. (2) Departamento de Ecología, CICESE Km 107, Highway Tijuana-Ensenada, Apdo. Postal 2732, Ensenada, B.C., México vidiaz@cicese.mx (2) Facultad de C. Biológicas, Universidad Autónoma de Nuevo León, Ap. Postal 5"F", San Nicolás de los Garza, Nuevo León, CP66451 México.

14. 4:00 **FECAL INDICATOR BACTERIA IN TIDAL WATERS OF THE BALLONA WETLANDS.** **John H. Dorsey.** Loyola Marymount University, Department of Natural Science, North Hall, Los Angeles, CA, 90045.

15. E 4:20 **AN ICP-MS STUDY OF CD, ZN AND CU ACCUMULATION IN THE BODIES, CYTOSOL AND JAWS OF THE POLYCHAETE, *NEANTHES ARENACEODENTATA*.** **Bernier, S.** and Mason, A.Z. Department of Biological Sciences and Institute for Integrated Research in Materials, Environments and Society, California State University Long Beach, CA, 90840.

16. 4:40 **REPRODUCTIVE BEHAVIOR OF THE MALE *NEANTHES ARENACEODENTATA* (ANNELIDA: POLYCHAETA).** **Donald J. Reish** and Karin De Collibus. Department of Biological Sciences, California State University, Long Beach, CA 90840.

Friday, May 14, 2004
Location: Union Ballroom A

Session: Pleistocene Paleontology

Chair: Mark Roeder, San Diego Natural History Museum

17. 1:40 **THE GYPSUM RIDGE LOCAL FAUNA, AN EARLY PLEISTOCENE VERTEBRATE ASSEMBLAGE FROM TWENTYNINE PALMS, SAN BERNARDINO COUNTY, CALIFORNIA.** **Hugh M. Wagner.** Dept. of Paleontology, San Diego Natural History Museum. P.O. Box 121390, San Diego, CA 92112.

18. 2:00 **A LATE PLEISTOCENE (RANCHOLABREAN) VERTEBRATE ASSEMBLAGE FROM OCEANSIDE, SAN DIEGO COUNTY, CA.** **K. A. Randall**, H. M. Wagner, B.O. Riney, M.A. Roeder. Department of Paleontology, San Diego Natural History Museum, 1788 El Prado, San Diego, CA 92101.

19. 2:20 **PLEISTOCENE VERTEBRATES OF THE LOS ANGELES BASIN AND VICINITY (EXCLUSIVE OF RANCHO LA BREA): AN UPDATE.** **Sherri M. Gust.** Cogstone Resource Management Inc.

20. 2:40 **A LARGE FOSSIL FLORA FROM THE PLEISTOCENE OLDER ALLUVIUM, TRIPLE M RANCH, CORONA, CALIFORNIA.** **L.H. Fisk**[1,2] and P.R. Peck[2]. [1]Department of Earth Sciences, American River College, Sacramento, CA, 95841 and [2]Paleo-Resource Consultants, 5325 Elkhorn Boulevard, #294, Sacramento, CA, 95842.

3:00 **BREAK**

21. 3:20 **DEPOSITIONAL HISTORY AND PALEOENVIRONMENT RECONSTRUCTION OF A MIOCENE MAMMAL AND BIRD TRACK SITE WITHIN BASIN FILL SEDIMENTS OF THE COPPER AND COFFIN CANYONS, DEATH VALLEY NATIONAL PARK, CA.** **T. Nyborg** and P.H. Buchheim. Department of Natural Sciences, Loma Linda University, Loma Linda, CA 92354.

22. 3:40 **FOSSIL MARINE FISH FAUNA FROM A LATE PLEISTOCENE SITE ON MISSION BAY, SAN DIEGO COUNTY, CALIFORNIA.** **Roeder, Mark A.** Department of Paleontology, San Diego Natural History Museum, P.O. Box 121390, San Diego, CA 92112.

23. 4:00 **RECENT SURVEY WORK NEAR EL GOLFO DE SANTA CLARA, SONORA MEXICO.** **C.A. Shaw**[1] and F.W. Croxon III[2]. [1]George C. Page Museum, Los Angeles, CA 90036 and[2] Western Arizona College, Yuma, AZ 85366.

24. 4:20 **EARLY RECORDS OF EXTINCT *BISON* FROM SOUTHERN CALIFORNIA AND THE BEGINNING OF THE RANCHOLABREAN NORTH AMERICAN LAND MAMMAL AGE.** **Eric Scott.** San Bernardino County Museum, Division of Geological Sciences, Redlands, CA 92374.

25. 4:40 **RALPH B. CLARK REGIONAL PARK: AN UNTAPPED TREASURE TROVE OF PLEISTOCENE FOSSILS.** **Lisa C. Babilonia.** Ralph B. Clark Interpretive Center, 8800 Rosecrans Ave., Buena Park, CA, 90621.

Friday, May 14, 2004
Location: Union Ballroom C

Session: Rocky Reef Habitats

Chair: Daniel Pondella, Occidental College and Bob Grove, SC Edison

26. 9:00 **SHOULD I STAY OR SHOULD I GONAD? SITE FIDELITY AND SEASONAL MOVEMENT PATTERNS OF CA SHEEPHEAD (*SEMICOSSYPUS PULCHER*).** **D.T. Topping**, C.G. Lowe, Y.P. Papastamatiou, and J. Caselle. California State University Long Beach, Deptartment of Biological Sciences, 1250 Bellflower Blvd., Long Beach, CA 90840, USA.

27. F 9:20 **THE FISH ASSEMBLAGES INSIDE AND OUTSIDE OF A MARINE RESERVE AT SANTA CATALINA ISLAND, CALIFORNIA.** **Froeschke, John T.** Nearshore Marine Fish Research Program, California State University, Northridge, Department of Biology, 18111 Nordhoff St. Northridge.

28. 9:40 **RECOMMENDATIONS FOR A RESERVE IN LA JOLLA BASED ON PATTERNS OF HABITAT, DIVERSITY, AND OCEANOGRAPHIC CLIMATE.** **P.E. Parnell**, C. Lennert-Cody, and P.K. Dayton. Scripps Institution of Oceanography, UCSD, La Jolla, CA, 92093-0227. CA, 91330.

28a. 10:00 **EFFECTS OF WARM WATER DISCHARGES FROM THE MORO BAY POWER PLANT ON HARD BOTTOM BENTHIC COMMUNITY STRUCTURE: FOLLOW-UP STUDIES TO DR. W.J. NORTH'S 1967/68 SURVEYS.** **Scott Kimura.** TENERA Environmental, San Luis Obispo, CA 93401.

28B. 10:20 **GETTING READY FOR THE "BIG ONE": NATIONAL OILSPILL DRILL IN SOUTHERN CALIFORNIA AND ATTEMPTS TO REDUCE NEARSHORE IMPACTS USING DISPERSANTS.** **A.J. Mearns.** Hazardous Materials Response Division, National Oceanic and Atmospheric Administration, Seattle, WA 98115.

10:40–11:00 **BREAK**

11:00–11:30 **Welcome, Student Grant Awards, Wheeler J. North Award.**

11:30–12:30 **Plenary Talk: IMPORTANCE OF POLYCHAETES Donald Reish, CSU Long Beach.**

12:30–1:40 **LUNCH BREAK**

29. 1:40 **STATUS OF THE KELP BEDS OF ORANGE AND SAN DIEGO COUNTIES IN 2002 WITH A REVIEW OF THEIR STATUS THROUGH 2003.** **Mike Curtis.** MBC Applied Environmental Sciences, Costa Mesa.

30. 2:00 **THE SAN CLEMENTE ARTIFICIAL REEF–EXPERIMENTAL PHASE KELP WRACK STUDY RESULTS.** **Robert Grove.** Environmental Projects, Southern California Edison, P.O. Box 800, Rosemed, CA 91770.

31. 2:20 **GLOBAL MONITORING OF TEMPERATE REEF ALGAL COMMUNITIES.** **Larry Deysher.** Ocean Imaging, 201 Lomas Santa Fe Drive, Suite 370, Solana Beach, CA 92075. Matt Edwards, San Diego State University.

32. 2:40 **EFFECTS OF BEACH REPLENISHMENT ACTIVITIES ON NEARSHORE MARINE HABITATS.** **L. Honma**[1] and R. Rundle[2]. [1]AMEC Earth & Environmental, 5510 Morehouse Dr., San Diego, CA 92121. [2]San Diego Association of Governments (SANDAG), 401 B Street Suite 800, San Diego, CA 92101.

3:00 **BREAK**

33. 3:20 **SIZE-DEPENDENT PREDATION ON TWO TEMPERATE-REEF FISHES: CAN CONFLICTING RESULTS FROM FIELD AND LAB STUDIES BE RECONCILED?** **M.A. Steele.** Marine Science Institute, University of California, Santa Barbara, CA 93106.

34. 3:40 **BIOGEOGRAPHY OF THE NEARSHORE ROCKY-REEF FISHES AT THE SOUTHERN AND BAJA CALIFORNIA ISLANDS.** **Daniel J. Pondella, II***, Brooke E. Gintert[2], Jana R. Cobb[1], and Larry G. Allen[3]. [1]Vantuna Research Group, Moore Laboratory of Zoology, Occidental College, 1600 Campus Rd., Los Angeles, CA 90041; [2]Rosenstiel School of Marine and Atmospheric Science, Marine Biology and Fisheries Division, Miami, 4600 Rickenbacker Causeway, Miami, FL 33149; [3]Department of Biology, California State University, Northridge, Northridge, CA 91330-8303.

35. 4:00 **RECRUITMENT OF REEF FISHES IN THE SANTA BARBARA CHANNEL.** **J.E. Caselle.** Marine Science Institute and PISCO, University of CA, Santa Barbara, CA 93106.

36. F 4:20 **TEMPORAL PATTERNS IN THE SETTLEMENT OF CRYPTIC REEF FISH.** **Joshua B. Lindsay.** Department of Biology, California State University, Northridge.

37. 4:40 **LARGE AND SMALL SPATIAL VARIATION IN CRYPTIC REEF FISH ASSEMBLAGES.** **J.R. Cobb.** Vantuna Research Group, Occidental College, 1600 Campus Road, Los Angeles, Ca. 90041.

Friday, May 14, 2004
Location: Alamitos Room

Session: Environmental Modelling

Chair: Drew Ackerman, SCCWRP

38. 9:00 **RECENT DEVELOPMENTS IN AUTOMATIC CALIBRATION AND APPLICATION TO HYDROLOGIC MODELING.** **Terri S. Hogue.** Department of Civil and Environmental Engineering, University of California-Los Angeles.

39. P 9:20 **MODELING WATER AND NUTRIENT EXPORT FROM COASTAL WATERSHEDS IN SOUTHERN CALIFORNIA.** **R.E. Beighley**, A. Leydecker, and J.M. Melack. Institute for Computational Earth System Science, University of California, Santa Barbara, CA 93106.

40. 9:40 **NUTRIENT MANAGEMENT IN THE SAN JACINTO WATERSHED, CALIFORNIA.** Rick Whetsel, Mark Norton, Santa Ana Watershed Project Authority, Riverside, CA. Andrew Parker, **Stephen Carter**, Tetra Tech, Inc., Fairfax, Virginia. Hope Smythe, Xinyu Li, Santa Ana Regional Water Quality Control Board, Riverside, CA.

41. 10:00 **HYDRODYNAMIC MODELING OF FECAL INDICATOR BACTERIA IN TALBERT MARSH BASED ON LOADS FROM URBAN RUNOFF, BIRD FECES, AND RESUSPENDED SEDIMENTS.** **Brett F. Sanders**†, Feleke Arega‡, and Martha Sutula.†† †Department of Civil and Environmental Engineering, University of California, Irvine; ‡Ecosystems Research Division, US Environmental Protection Agency; ††Southern California Coastal Water Research Project.

42. 10:20 **DYE DISPERSION IN THE SURF ZONE: MEASUREMENTS AND SIMPLE MODELS.** **L. B. Clarke**, J. Largier, Integrative Oceanography Department, Scripps Institution of Oceanography, University of California-San Diego, La Jolla, CA. D. Ackerman, Southern California Coastal Water Research Project, Westminster, CA.

10:40 **BREAK**

11:00 **Welcome, Student Grant Awards, Wheeler J. North Award.**

11:30 **Plenary Talk: IMPORTANCE OF POLYCHAETES Donald Reish, CSU Long Beach.**

Friday, May 14, 2004
Location: Alamitos Room

Session: Contributed Papers

Chair: Tonny Wijte, CSU Long Beach

43. E 1:40 **SPATIAL AND TEMPORAL VARIATION IN THE TISSUE HALIDE CONTENT OF THE COASTAL SALT MARSH HALOPHYTE, *SALICORNIA VIRGINICA.*** **Y. J. Ralph.** California State University, Long Beach, Department of Biology, Long Beach, Ca, 90840.

44. E 2:00 **EFFECTS OF DISPERSAL ON LOCAL DISTRIBUTION OF THE GRANITE SPINY LIZARD, *SCELOPORUS ORCUTTI.*** **A.M. Fox** and J.W. Archie. California State University, Long Beach, Department of Biological Sciences, Long Beach, CA, 90840.

45. 2:20 **GEOLOGY AND PETROLOGY OF A MIOCENE DACITE DIKE SWARM AND COGENETIC VOLCANIC ROCKS, LITTLE CHUCKWALLA MOUNTAINS, CALIFORNIA.** **Angelique C. Hamane** and Dave Mayo. California State University, Los Angeles, Department of Geological Sciences, 5151 State University Drive, Los Angeles, CA 90032.

47. P 2:40 **JOINT DYNAMICS OF THE EQUINE FORELIMB DURING JUMPING.** **SS Huber**, DF Hoyt, DJ Dutto, SJ Wickler. Departments of Biological Sciences, Kinesiology & Health Promotion, and Animal & Veterinary Science California State Polytechnic University, Pomona, CA, 91768.

3:00–3:20 **BREAK**

48. 3:20 **SUMMERTIME DISTRIBUTION OF THREE SPECIES OF ATHERINOPSID FISHES IN EAST-CENTRAL SAN FRANCISCO BAY.** **A. Jahn**, Port of Oakland, and E. Jolliffe, U. S. Army Corps of Engineers, San Francisco District.

49. F 3:40 **STANDARD AND ROUTINE METABOLISM OF KELP BASS *PARALABRAX CLATHRATUS.*** **K. Johnson.** California State University, Long Beach, Department of Biological Sciences, Long Beach, CA, 90815.

50. P 4:00 **MASS SIZE DISTRIBUTIONS AND DRY DEPOSITION FLUXES OF TRACE METALS MEASURED IN THE LOS ANGELES AIR BASIN.** **Jeong-Hee Lim** and Keith D. Stolzenbach, Department of Civil and Environmental Engineering, University of California, Los Angeles, Los Angeles, CA, 90095. Lisa D. Sabin and Kenneth Schiff, Southern California Coastal Water Research Project, 7171 Fenwick Lane, Westminster, CA 92683.

51. M. 4:20 **GENE EXPRESSION OF AMYLASE BY *IN SITU* HYBRIDIZATION IN CARNIVOROUS AND HERBIVOROUS PRICKLEBACK FISHES: ONTOGENETIC, DIETARY, AND PHYLOGENETIC EFFECTS.** **K.H. Kim** and M.H. Horn. California State University, Fullerton, Department of Biological Science, Fullerton, CA, 92834.

Friday, May 14, 2004
Location: Center Courtyard of the University Student Union

Session: Poster Session and Wine and Cheese Social

52. P **A PETROGRAPHIC ANALYSIS OF A PALEOSOL IN THE LAS VIRGENES SANDSTONE, SANTA MONICA MOUNTAINS.** ***E. Abeja**, *P.C. Ramirez, *M. Banda, **H. Hernandez, *G. Noriega. *California State University Los Angeles, Department of Geological Sciences, Los Angeles, CA, 90032; **University of Southern California, Department of Earth Sciences, Los Angeles, CA 90089.

53. P **GEOCHEMICAL ANALYSIS OF THE RICARDO VOLCANICS, SOUTHERN EL PASO MOUNTAINS, CALIFORNIA.** **Cami Jo Anderson** and David R. Jessey. Department of Geological Sciences, California State Polytechnic University–Pomona, Pomona, CA, 91768.

54. E **TESTING DIET SWITCHING AS THE MECHANISM FOR THE EVOLUTION OF STRICT HERBIVORY IN LIZARDS.** **D. L. Andres** and R. E. Espinoza. Laboratory for Integrative and Comparative Herpetology, Department of Biology, California State University, Northridge, Northridge, CA 91330-8303.

55. P **A POSSIBLE ORIGIN FOR A PALEOCENE QUARTZ-RICH SANDSTONE ASSOCIATED WITH A PALEOCENE PALEOSOL IN THE SAN JOAQUIN HILLS, CALIFORNIA.** **M. Banda**, P. Ramirez, S. Leyva, and E. Abeja. California State University, Los Angeles, Department of Geological Sciences, Los Angeles, California 90032.

56. E **PUDDINGSTONE RESEVOIR PLANKTON POPULATION STUDIES, OCTOBER 2002-APRIL 2003.** **F. M. Bell** and S. V. Merritt. University Of La Verne, Department of Biology, La Verne California.

57. E **GENETIC DIFFERENTIATION WITHIN AND AMONG PYGMY NUTHATCH (*SITTA PYGMAEA*) POPULATIONS IN SOUTHERN CALIFORNIA.** **T.A. Benson** and A.E. Metcalf. Department of Biology, California State University, 5500 University Parkway, San Bernardino, CA 92407.

58. E ***E. COLI* AND *ENTEROCOCCUS* IN SURFACE WATERS OF EAST SAN GABRIEL RIVER WATERSHED: LEVELS OF CONTAMINATION IN THREE FLOOD CONTROL CHANNELS AND SAN DIMAS CANYON CREEK.** **Victor M. Delgado** and S. V. Merritt. Biology Dept., University of La Verne, La Verne, CA 91750.

59. P **ASSESSING THE POTENTIAL FOR PALEOCLIMATE STUDIES IN CRYSTAL LAKE, SOUTHERN CALIFORNIA.** **M.B. DeRose** and M.E. Kirby. California State University, Fullerton, Department of Geological Sciences, Fullerton, CA 92834.

60. E **SEASONAL BACTERIAL CONCENTRATIONS IN THE LONG BEACH/LOS ANGELES HARBOR COMPLEX.** **K. E. Flaherty**, C. V. Wolfe, K. A. Snow, K. Kull, and R. E. Pieper. Southern California Marine Institute, Terminal Island, CA, 90371.

61. M **ISOLATION AND CHARACTERIZATION OF MICROSATELLITE LOCI OF YELLOWFIN GOBY, *ACANTHOGOBIUS FLAVIMANUS*.** **E.M. Gallardo** and R.R. Wilson, Jr. California State University, Long Beach, Department of Biological Sciences, Long Beach, CA 90840.

62. E **EFFECTS OF LIGHT AND TEMPERATURE ON PHOTOSYNTHETIC RESPONSES OF THE INVASIVE INTERTIDAL SEAWEED *CAULACANTHUS USTULATUS* (RHODOPHYTA).** **V. G. Galvan** and S. N. Murray. Department of Biological Science, California State University, Fullerton, Fullerton, CA, 92834-6850.

63. **THE STATE OF SAN DIEGO BAY IN 1998: ECOLOGICAL CONDITIONS.** **A.K. Groce**, D. Pasko, D.A. Ituarte, E.C. Nestler, R.J. Gartman, T.D. Stebbins, R.N. Haring. City of San Diego Ocean Monitoring Program, San Diego, CA, 92101.

64. E **LOSS OF *accD* GENE FROM CHLOROPLAST GENOMES.** **M.E. Harris**, G. Meyer, V.M. Vandergon, and T. Vandergon. California State University, Northridge, Department of Biology, Northridge, CA, 91330.

65. M **THE EFFECTS OF EXCESS ZINC ON DEVELOPING MURINE THYMOCYTES.** **Thomas H. Hatch** and Christine Broussard. University of La Verne, Department of Biology, La Verne, CA, 91750.

66. **SCRIPPS INSTITUTION OF OCEANOGRAPHY BENTHIC INVERTEBRATES COLLECTION.** **L. L. Lovell.** Senior Collection Manager, Scripps Institution of Oceanography, 9500 Gilman Drive La Jolla, CA 92093-0244.

67. **CLONING OF YEAST ENV GENES RESPONSIBLE FOR LYSOSOMAL PROTEIN TRAFFICKING AT A POST-GOLGI, PRE-VACUOLAR COMPARTMENT.** [1]**C. Frost**, [2]**M. Garcia**, [2]**C. Funiciello**, [2]**L. McLennan**, [2]E. Gharakhanian. [1]Department of Chemistry and Biochemistry; [2]Department of Biological Sciences, California State University, Long Beach, Long Beach, CA 90840.

68. **SEDIMENT CONDITIONS WITHIN SAN DIEGO BAY–RESULTS OF BIGHT'98 REGIONAL SURVEY.** Dean Pasko, Daniel A. Ituarte, Eric C. Nestler, **Ami K. Groce**, Timothy D. Stebbins, R. Nicholas Haring. City of San Diego Ocean Monitoring Program, San Diego, CA 92101.

69. E **STRUCTURE OF THE BENTHIC MACROFAUNA IN BAHÍA SANTA ROSALIITA, BAJA CALIFORNIA, MÉXICO.** **V. Rodríguez-Villanueva**[1], R. Martínez-Lara[2], and M. Mondragón-Rojas[3]. [1]Facultad de Ciencias Marinas. Instituto de Investigaciones Oceanológicas (I.I.O). Universidad Autónoma de Baja California (UABC). Km 107 Carretera Tijuana-Ensenada. Ensenada, B.C. México. Apdo. Postal 453; [2]Marine Biology Laboratory, City of San Diego Ocean Operations, 2392 Kincaid Rd, San Diego, California 92101-0811. USA; [3]CISESE. Km 107 Carretera Tijuana-Ensenada. Ensenada, B.C. México. Apdo. Postal 2732.

70. E **MALE MORPHOLOGY AND CALLING SONG CHARACTERSTICS IN THE FIELD CRICKET, GRYLLUS BIMACULATUS.** **R Sison**, N. R. Moradian, E. Cole and S. E. Walker. Department of Biological Science, California State University, Fullerton, Fullerton, CA 92834-6850.

71. E **MOLECULAR EVOLUTION OF THE CHALCONE SYNTHASE GENE FAMILY IN *DUBAUTIA LINAERIS* (HAWAIIAN SILVERSWORD).** **S. J. Smith** and V.O. Vandergon. California State University, Northridge, Department of Biology, Northridge, CA 91330.

72. E **PHYLOGEOGRAPHY OF *NORRISIA NORRISI* IN THE SOUTHERN CALIFORNIA BIGHT, WITH AN EMPHASIS ON GENETIC VARIATION BETWEEN DISTURBED AND UNDISTURBED HABITATS.** **Michelle Stabio.** California State University, Los Angeles.

73. M **MOLECULAR ANALYSIS OF GENETIC VARIATION IN THE FEDERALLY ENDANGERED *ASTRAGALUS JAEGERIANUS* (FABACEAE, PAPILIONOIDEAE): A SPECIES WITH A RESTRICTED GEOGRAPHIC RANGE.** **G.F. Walker** and A.E. Metcalf. California State University, San Bernardino, Biology Department, San Bernardino, CA 92407.

74. **THE ROLE OF PLANT-SOIL FEEDBACKS IN COASTAL SAGE SCRUB RESTORATION ON SANTA CRUZ ISLAND, CA.** **Stephanie Yelenik.** Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, CA 93107.

75. **THE EFFECT OF SUBSTRATE SALINITY ON THE GROWTH OF *SALICORNIA VIRGINICA* L.** **Crystal Marquez**[1,2], Tori Matthys[2], Christine Der[2], and Philippa M. Drennan[2]. [1]US Army Corps of Engineers and [2]Loyola Marymount University, Biology Department, Los Angeles, CA 90045.

Saturday, May 15, 2004
Location: Union Ballroom A

Session: Molecular Ecology

Chair: Ray Wilson, CSU Long Beach

76. 9:00 **PHYLOGEOGRAPHY AND PATTERNS OF GENETIC DIFFERENTIATION IN THE WESTERN FENCE LIZARD, *SCELOPORUS OCCIDENTALIS,* IN SOUTHERN CALIFORNIA.** **James W. Archie.** Department of Biological Sciences, California State University, Long Beach, CA 90840.

77. E 9:20 **MOLECULAR ECOLOGY OF A RIPARIAN AMPHIBIAN IN SOUTHERN CALIFORNIA: THE CALIFORNIA TREEFROG (*PSEUDACRIS CADAVERINA*).** **I.C. Phillipsen** and A.E. Metcalf. Department of Biology, California State University, 5500 University Parkway, San Bernardino, CA 92407.

78. 9:40 **NUCLEAR GENE FLOW IN AREAS OF PRESUMED SECONDARY CONTACT IN THE WESTERN FENCE LIZARD, *SCELOPORUS OCCIDENTALIS* IN THE SAN GABRIEL MOUNTAINS OF SOUTHERN CALIFORNIA.** **T. J. Vail.** California State University, Long Beach, Department of Biological Sciences, 1250 Bellflower Blvd., Long Beach, CA 90840.

79. 10:00 **ECOLOGICAL GENETICS OF THE TIDEPOOL COPEPOD *TIGRIOPUS CALIFORNICUS.*** **S. Edmands**, J. Deimler and J.S. Harrison. University of Southern California, Department of Biological Sciences, Los Angeles, CA, 90089.

80. E 10:20 **CONTRASTING DISPERSAL IN TWO CALIFORNIA ABALONE SPECIES USING A POPULATION GENETIC APPROACH.** **K.M. Gruenthal** and R.S. Burton. Marine Biology Research Division, Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, 92037.

10:40 **BREAK**

11:00 **Plenary Talk: NOAH'S FLOOD: MYTH OR HISTORICAL REALITY. Dr. Walter C Pitman III, Lamont-Doherty Earth Observatory, Columbia University.**

12:00–1:20 **LUNCH BREAK**

Saturday, May 15, 2004
Location: Union Ballroom A

Session: Molecular Ecology

Chair: Ray Wilson, CSU Long Beach

81. 1:20 **DIVERSITY, HISTORY, AND PHYLOGEOGRAPHY OF THE NORTHEASTERN PACIFIC COAST.** D. K. Jacobs, **T. A. Haney**, and K. D. Louie. Department of Organismic Biology, Ecology and Evolution, University of California Los Angeles, Los Angeles, CA, 90007.

82. 1:40 **STOCK STRUCTURE ANALYSES OF SPOTTED DOLPHINS IN THE EASTERN TROPICAL PACIFIC OCEAN REVEAL A HIGH DEGREE OF FEMALE PHILOPATRY.** **S. Escorza-Treviño**[1,2], M. Rosales[1], A. Lang[2], and A.E. Dizon[2]. (1) Department of Biological Sciences, California State University, 5151 State University Dr. Los Angeles, CA 90032. (2) Southwest Fisheries Science Center. 8604 La Jolla Shores Dr. La Jolla, CA 92038.

83. 2:00 **THE EFFECTS OF DISPERSAL AND HABITAT PREFERENCES ON SPECIATION IN CARIBBEAN MARINE OSTRACODES.** **E. Torres** and D.G. Valdez. Center for Environmental Analysis, Department of Biological Sciences, California State University, Los Angeles, CA, 90032-8201.

84. E 2:20 **APPLICATION OF BEAD ARRAY TECHNOLOGY TO COMMUNITY DYNAMICS OF MARINE PHYTOPLANKTON.** **C.K. Ellison** and R.S. Burton. Marine Biology Research Division, Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA 92037-0208.

84a. F 2:40 **GENETIC DIFFERENTIATION OF THE BIOLUMINESCENT MARINE FISH *PORICHTHYS NOTATATUS* (BATRACHOIDIDAE).** Elizabeth Torres, Department of Biology and Microbiology, California State University Los Angeles, Los Angeles, CA, USA. **Imelda L. Nava**, Department of Organismic Biology, Ecology, and Evolution, University of California Los Angeles, Los Angeles, CA, USA.

3:00 **BREAK**

85. E 3:20 **WHAT MTDNA TELLS US ABOUT THE INAVSION HISTORY OF YELLOWFIN GOBY IN CALIFORNIA–PART I: THROUGH THE BOTTLE'S NECK?** **M.E. Neilson** and R.R. Wilson, Jr. California State University Long Beach, Department of Biological Sciences, Long Beach, CA 90840.

86. 3:40 **WHAT MTDNA TELLS US ABOUT THE INVASION HISTORY OF YELLOWFIN GOBY IN CALIFORNIA–PART II: HOW MANY INVASIONS?** M.E. Neilson and **R.R. Wilson, Jr.** California State University, Long Beach, Department of Biological Sciences, Long Beach, CA 90840.

87. 4:00 **MICROSATELLITE ALLELE FREQUENCY ANALYSIS OF *ACANTHOGOBIUS FLAVIMANUS:* EVIDENCE FOR POSSIBLE GENE FLOW BETWEEN SAN FRANCISCO BAY AND TOKYO BAY.** **A.R. Beck**, E.M. Gallardo, J.L. Dickens, M.E. Neilson, and R.R. Wilson Jr. California State University, Long Beach, Department of Biology, Long Beach, CA, 90840.

Saturday, May 15, 2004
Location: Union Ballroom B

Session: Stress Responses in Fish

Chair: Kevin Kelly and Chris Lowe, CSU Long Beach

88. 9:00 **INTRODUCTION TO THE SYMPOSIUM–ITS PURPOSE AND PLAN.** **K.M. Kelley** and C.G. Lowe. Marine Biology Program, Department of Biological Sciences, California State University, Long Beach, Long Beach, CA 90840.

89. 9:20 **THE FISH CASE-STUDY OF THE VERTEBRATE STRESS RESPONSE AND ITS RELEVANCE TO HUMAN-DERIVED IMPACTS IN MARINE FISHES. K.M. Kelley**[1], M.M. Galima[1], J.A. Reyes[1], K. Sak[1], D. Topping[1], K. Goldman[2], and C.G. Lowe[1]. [1]Marine Biology Program, Dept. Biological Sciences, California State University, Long Beach, Long Beach, CA 90840; [2]Jackson State Univ., Dept. of Biology, P.O. Box 18540, Jackson, MS 39217.

90. 9:40 **REGULATION OF STRESS STEROIDS IN MAMMALS AND FISH: COMMON MECHANISMS AND DIFFERENCES. M.E. Baker.** Department of Medicine – 0693, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA 92093-0693.

91. 10:00 **CATCH-AND-RELEASE STRESS: IMPACTS ON THE ENDOCRINE PHYSIOLOGY OF THE CALIFORNIA SHEEPHEAD, *SEMICOSSYPHUS PULCHER*. M.M. Galima** C.G. Lowe, and K.M. Kelley. Department of Biological Sciences, California State University Long Beach, Long Beach, CA, 90840.

92. F 10:20 **PARASITES OF FISHES ASSOCIATED WITH WASTEWATER DISCHARGE AND THE POTENTIAL OF INFESTATION AND STRESS ON HOST FISHES. J.E. Kalman.** University of California Los Angeles, Department of Organismic Biology, Ecology and Evolution, Los Angeles, CA 90095 and Orange County Sanitation District, Environmental Compliance and Monitoring Division, Fountain Valley, CA 92708.

10:40–11:00 **BREAK**

11:00–12:00 **Plenary Talk: NOAH'S FLOOD: MYTH OR HISTORICAL REALITY. Dr. Walter C Pitman III, Lamont_Doherty Earth Observatory, Columbia University.**

12:00–1:20 **LUNCH BREAK**

93. F 1:20 **ALTERED ENDOCRINE PHYSIOLOGY OF SOUTHERN CALIFORNIA FLATFISH COLLECTED NEAR WASTEWATER TREATMENT PLANT (WWTP) OUTFLOW–STRESS AND GROWTH. J.A. Reyes**[1], K. Sak[1], M.M. Galima[1], J.L Armstrong[2], and K.M. Kelley[1]. [1]Endocrine Laboratory & Marine Biology Program, Dept. Biological Sciences, California State University, Long Beach, Long Beach, CA 90840; [2]Orange County Sanitation District, Fountain Valley, CA, 92708.

94. 1:40 **INTEGRATING PHYSIOLOGICAL AND BEHAVIORAL RESPONSES OF CALIFORNIA SHEEPHEAD EXPOSED TO FISHING-RELATED STRESSORS AND ITS IMPLICATIONS TOWARDS MANAGEMENT. C.G. Lowe**[1], D.T. Topping[1], M.M. Galima[1], K.J. Goldman[2], and K.M. Kelley[1]. [1]Dept. of Biological Sciences, CSU Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840, clowe@csulb.edu, 562-985-4918. [2]Jackson State Univ., Dept. of Biology, P.O. Box 18540, Jackson, MS 39217.

95. 2:00 **GROWTH AND SURVIVAL IN JUVENILE WHITE SEABASS CAUGHT-AND-RELEASED ON OFFSET CIRCLE AND J-TYPE HOOKS. S.A. Aalbers,**[1] G.M. Stutzer,[2] and M.A. Drawbridge.[1] [1]Hubbs-SeaWorld Research Institute 2595 Ingraham St. San Diego, CA. 92109; [2]CSU San Marcos, 333 S. Twin Oaks Valley Rd. San Marcos CA 92096.

96. 2:20 **MOLECULAR INDICATORS OF CAPTURE RELATED STRESS IN SHARKS. D. Bernal** and J. Smith. Weber State University, Department of Zoology, Ogden, UT, 84408.

97. 2:40 **THE PHYSIOLOGICAL EFFECTS OF CAPTURE STRESS IN TUNAS, BILLFISHES, AND SHARKS WITH INFERENCES ON POST-RELEASE RECOVERY. G.B. Skomal.** Massachusetts Division of Marine Fisheries, Martha's Vineyard Research Station, P.O. Box 68, Vineyard Haven, MA, 02568.

3:00–3:20 **BREAK**

98. 3:20 **CATCH AND RELEASE STRESS IMPACTS ON FISH: INTEGRATING RESEARCH FINDINGS INTO MANAGEMENT DECISIONS AND ANGLER CATCH AND RELEASE PRACTICES. S.F. Theberge.** Oregon Sea Grant, Clatsop County Extension Office, OSU Seafood Laboratory Astoria, OR, 97103.

3:40–4:00 **DISCUSSION–OPEN PANEL I. Additional and/or Future Questions, Overall Conclusions, Recommendations.**

4:00–4:20 **DISCUSSION–OPEN PANEL II. (Additional time if necessary).**

Saturday, May 15, 2004
Location: Union Ballroom C

Session: Molecular Biology of Cellular Processes

Chair: Editte Gharakhanian

99. 9:00 **CHARACTERIZATION OF LIGHT HARVESTING-DEPENDENT, CHLOROPLAST LOCALIZED AtcDPPIV DIPEPTIDYL AMINOPEPTIDASE IN *ARABIDOPSIS THALIANA*.** **J. A. Brusslan**, S. E. Martini, and H.-I. Lee. Department of Biological Sciences, California State University, Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840-3702.

100. M 9:20 **HIGH-LIGHT INDUCIBILITY RETAINED IN A 216 BP FRAGMENT OF THE *ARABIDOPSIS ELIP1* PROMOTER.** **Gorjana Bezmalinovic**, Livier Corado, Judy A. Brusslan. California State University, Long Beach, Department of Biological Sciences, Long Beach, CA, 90840.

101. 9:40 **VESICULAR TRANSPORT TO THE YEAST LYSOSOMAL VACUOLE.** **Editte Gharakhanian.** CSULB, Dept. of Biological Sciences.

103. 10:00 **TARGETING OF NEUROLIGIN IN CULTURED HIPPOCAMPAL NEURONS.** **C. R. Rosales**[1], K. O. Osborne[1], P. Scheiffele[2], M. A. Silverman[1]. California State Polytechnic University, Pomona, Department of Biological Sciences, CA, 91768.[1] Columbia University, Center for Neurobiology and Behavior, NY, 10032.[2]

10:40 **BREAK**

11:00 **Plenary Talk: NOAH'S FLOOD: MYTH OR HISTORICAL REALITY. Dr. Walter C Pitman III, Lamont_Doherty Earth Observatory, Columbia University.**

Saturday, May 15, 2004
Location: Union Ballroom C

Session: Archaeology of Southern California

Chair: Andrea P. Murray, California State University, Fullerton

104. 1:20 **PRELIMINARY RESULTS FROM ANAVERDE VALLEY.** **Sherri M. Gust** and Vanessa Mirro. Cogstone Resource Management Inc., Santa Ana, CA 92701.

105. 1:40 **PRESERVING ORANGE COUNTY'S ARCHAEOLOGICAL LEGACY.** **Andrea P. Murray.** Department of Anthropology, California State University, Fullerton, CA 92834.

106. 2:00 **THE USE OF FIRED-CLAY DAUB FROM CA-ORA-269 IN THE IDENTIFICATION OF PREHISTORIC DWELLING CONSTRUCTION METHODS, SAN JOAQUIN HILLS, ORANGE COUNTY, CALIFORNIA."** **Ivan H. Strudwick.** LSA Associates, Inc.

107. 2:20 **ROCK ART AND SOCIAL RITUALS: FEMALE PUBERTY CEREMONIES AND PETROGLYPH MOTIFS AMONG NATIVE CALIFORNIANS.** **D. Barter**, B. Butler, S. Fulsom, G. Gonzalez, A. Martinez, C. Potts, C. Purtell, and R. Yamashita. Department of Anthropology, California State University Dominguez Hills, 1000 E. Victoria St., Carson, CA 90747.

108. 2:40 **THE ARCHAEOLOGY OF REGIONS: AN INITIAL REPORT OF THE WESTERN SANTA MONICA MOUNTAINS-OXNARD PLAIN PROJECT.** **C. Delaney-Rivera.** California State University-Fullerton, Department of Anthropology, Fullerton, CA 92834.

3:00 **BREAK**

109. 3:20 **LARGE FRACTION FISH MATERIAL FROM SLO-2: FITCH (1972) REVISITED.** - **J.W. Gaeta** and K.W. Gobalet. Department of Biology, California State University, Bakersfield, CA 93311.

110. 3:40 **THE TALEGA SITE AND ENCINITAS TRADITION PREHISTORY IN ORANGE COUNTY.** **David D. Ferraro.** Viejo California Associates, 22512 Via Loyola, Mission Viejo CA.

111. 4:00 **THE CHIPPED STONE TOOLS OF CA-ORA-840, A MILLINSTONE HORIZON SITE IN SOUTHERN ORANGE COUNTY.** **Natalie Lawson.** LSA Associates, 1650 Spruce St, Riverside, CA 92507.

112. 4:20 **BOTANICAL TERMS AMONG THE UTO-AZTECAN SPEAKERS OF SOUTHERN CALIFORNIA.** **Stephen O'Neil.** SWCA Environmental Consultants, 23392 Madero, Mission Viejo, California, 92691.

113. 4:40 **FISHING AND MARINE MAMMAL HUNTING PATTERNS FROM A 2500-YEAR OLD CAMPSITE ON SAN NICOLAS ISLAND.** **S.R. James.** Department of Anthropology, California State University at Fullerton, P.O. Box 6846, Fullerton, CA 92834-6846.

Saturday, May 15, 2004
Location: Alamitos Room

Session: Contributed Papers

Chair: John Roberts, CSU Dominguez Hills

114. E 9:00 **THE ROLE OF MACROPHYTES IN THE DIETS OF THE SUSPENSION-FEEDING MUSSEL *MYTILUS CALIFORNIANUS* ON SOUTHERN CALIFORNIA SHORES: A CARBON ($\delta^{13}C$) AND NITROGEN ($\delta^{15}N$) STABLE ISOTOPE ANALYSIS.** **L. Gilbane** and S. N. Murray. Department of Biological Science, California State University, Fullerton, California, 92834-6850.

115. F 9:20 **AGE AND GROWTH OF THE ROUND STINGRAY, *UROBATIS HALLERI*, AT SEAL BEACH, CALIFORNIA.** **Lori Hale.** California State University Long Beach, Department of Biological Sciences, CA 90840, lhale@csulb.edu.

116. E 9:40 **ASPECTS OF THE LIFE HISTORY OF THE BLACK CROAKER (*CHEILOTREMA SATURNUM*) FROM WITHIN THE SOUTHERN CALIFORNIA BIGHT.** **Miller, Eric F.** California State University, Northridge, Northridge, CA.

118. F 10:00 **GENE FLOW AMONG SPOTTED SAND BASS, *PARALABRAX MACULATOFASCIATUS*, POPULATIONS WITHIN THE SOUTHERN CALIFORNIA BIGHT.** **M. P. Salomon.** Department of Biology, California State University Northridge, Northridge, CA, 91330.

117. 10:20 **MICROHABITAT COLOR PREFERENCES OF FOUR *TEGULA* SPECIES IN DANA POINT, CALIFORNIA.** **G.K. Nishiyama** and C.A. Kay-Nishiyama. College of the Canyons, Santa Clarita, California 91355.

Saturday, May 15, 2004
Location: Science Lecture Hall 48

Session: Research Training Program: Session I

Chair: Richard Schwartz

119. 8:40 **THE *CYP1B1* L432V POLYMORPHISM AND RISK OF COLORECTAL CANCER.** **Gloria Chi.** Alhambra High School.

120. 9:00 **THE EFFECTS OF DYNEIN AND KINESIN ON THE INTRACELLULAR MOVEMENTS IN THE PARIETAL CELLS.** **J. Gov** and C.T. Okamoto. Department of Pharmaceutical Sciences, School of Pharmacy, University of Southern California, Los Angeles, California 90089-9121.

121. 9:20 **ANALYSIS OF FERRITIN EXPRESSION IN VARIOUS CELL LINES WITH FLOW CYTOMETRY.** **Serena Ann Lee.** University of Southern California Keck School of Medicine, Department of Pathology, Los Angeles, CA, 90089.

122. 9:40 **IDENTIFYING NEURAL REGIONS RESPONSIBLE FOR LIFESPAN IN DROSOPHILA.** **Maham Ahmad.** 501 N Chapel #1, Alhambra CA. Alhambra High School, Alhambra, CA 91801. Mentor/Teacher: David Walker [Benzer Lab, Caltech]; Duane Nichols [Alhambra High School].

123. 10:00 **THE EFFECTS OF PROGESTIN ON THE HORMONE RECEPTOR CONTENT OF HUMAN ENDOMETRIAL EXPLANTS.** **Dorothy Chan.** Alhambra High School, Mentor: Dr. Juan C. Felix.

124. 10:20 **INHIBITING THE GROWTH OF AN EWING SARCOMA TUMOR CELL LINE USING SIRNAS DELIVERED AS COMPLEXES TO CDPS THAT TARGET THE EWS/FLI-1 ONGOGENIC FUSION GENE.** **S.B. Ha** and J. D. Heidel. Mark E. Davis Research Group, California Institute of Technology, Department of Chemical Engineering, Pasadena, CA, 91125.

10:40 **BREAK**

11:00 **Plenary Talk: NOAH'S FLOOD: MYTH OR HISTORICAL REALITY. Dr. Walter C Pitman III, Lamont_Doherty Earth Observatory, Columbia University.**

12:00–1:20 **LUNCH BREAK**

Saturday, May 15, 2004
Location: Science Lecture Hall 48

Session: Research Training Program: Session I

Chair: Martha Schwartz

125. 1:20 **PROGESTERONE RECEPTOR EXPRESSION AND LOCALIZATION IN ADULT MONKEY TESTES.** **Brittany Hahn**, Yan-He Lue, M.D., Christina Wang, M.D., Ronald Swerdloff, M.D. Palos Verdes Peninsula High School and Div. of Endocrinology, Dept. of Medicine, Harbor-UCLA Medical Center Research and Education Institute, Torrance, California.

126. 1:40 **THE DISTRIBUTION AND BINDING PARTNERS OF KINESIN II IN RABBIT LACRIMAL ACINI.** **J. Hu.** USC Medical Center, School of Pharmacy, Department of Cell Biology, Los Angeles, CA, 90033.

127. 2:00 **SUSCEPTIBILITY OF OXIDATIVELY CROSSLINKED AMYLOID BETA-PROTEIN TO INSULIN-DEGRADING ENZYME.** **J. Young.** Alhambra High School, USC School of Pharmacy, Department of Pharmaceutical Sciences, Los Angeles, CA, 90089-9121.

128. 2:20 **DETECTING SNPs IN EXON 1 OF THE *HOXA10* GENE OF CRYPTORCHID PATIENTS.** **C. Tat**, D. Ren, A.T. Diep, and V. Cortessis. USC Haile's Lab, USC/Norris Cancer, Department of Genetics/Epidemiology, Los Angeles, 90033.

129. 2:40 **PHAGOCYTOSIS AND CYTOTOXICITY OF NICKEL OXIDE.** **Janey Yu.** University of Southern California, USC/Norris Comprehensive Cancer Center Keck Scohol of Medicine, Cancer Research Laboratory, 1301 North Mission Road, Room #218, Los Angeles, CA 90031.

3:00 **BREAK**

130. 3:20 **HIPPOCAMPAL EXPRESSION OF BDNF 5′ EXONS IN AGED FISHER RATS.** **Robin Zhou.** Alhambra High School, Alhambra, California
Mentor: Dr. Amelia Russo-Neustadt.

131. 3:40 **EFFECTS OF PHOSPHATE ON THE BIOLOGICAL PROCESSES OF TRICHODESMIUM.** **S.F. Ong**[1], J. Sohm[2], and D. Capone[2]. [1]California Academy of Mathematics and Science, Carson, CA; [2]Wrigley Institute of Environmental Biology, University of Southern California, Department of Biological Sciences, Los Angeles, CA.

131a. 4:00 **GENE MUTATION IN DYDKERATOSIS CONGENITA- STUDY OF EXON 8.** **Samir Mehrotra**, Viewpoint School, Calabasas, CA 91302. Marisa Briones, Pavel Lieb, Dr. Aida Metzenberg, California State University at Northridge, Northridge, CA 91330.

4:30 **Presentation by students who went to National AAJAS Meeting and student Intel Science Contentants; Joon-Bok (James) Lee, Su Fey Ong, Ved Chirayeth, Eddie Smetak and Genevieve Williams. Meeting will occur in Alamitos Room, Student Union.**

Saturday, May 15, 2004
Location: Science Lecture Hall 50

Session: Research Training Program: Session II

Chair: Kathy Phalen

132. 8:40 **SYNTHESIS OF PALLADIUM NANOWIRES BY ELECTRODEPOSITION ONTO HIGHLY ORIENTED PYROLITIC GRAPHITE.** **Kaidi He.** University High School, Irvine.

133. 9:00 **THE CHEMICALLY DEFINABLE DIFFERENCES BETWEEN WATER WASH AND NON-WATER WASH SYSTEM IN ANAYLSIS OF WATER CONTENT.** **L. Huang**, A. Chu, and C. Tan, II. The Bio-Diesel Team, Gabrielino High School, Department of Technology, San Gabriel, CA, 91776.

134. 9:20 **ALGORITHM PERFORMANCE ON THE SATISFIABILITY PROBLEM.** **Timothy L. Uy** and Dennis Kibler. University of California: Irvine, Department of Computer Science, Irvine, California 92697-3425.

135. 9:40 **DESIGN AND CREATION OF A LOW-COST VOLUMETRIC DISPLAY DEVELOPMENT SYSTEM.** **Michael McDaniels.** California Academy of Math and Science.

136. 10:00 **MICROBIAL RESPONSE TO EXPOSURE FORM VARIOUS STRESSORS.** **Sanyl Kabre.** 4508 W 133rd St. Hawthorne, CA, 90250.

137. 10:20 **STRAIN RELATEDNESS OF *CANDIDA* IN HUMANS: A URINARY PATHOGEN OR COLONIZER?** **Joon-Bok Lee.** Division of Infectious Diseases, Los Angeles County Harbor-UCLA Medical Center, 1000 W. Carson Street, Torrance, California 90502.

10:40 **BREAK**

11:00 **Plenary Talk: NOAH'S FLOOD: MYTH OR HISTORICAL REALITY. Dr. Walter C Pitman III, Lamont_Doherty Earth Observatory, Columbia University.**

12:00–1:20 **LUNCH BREAK**

Saturday, May 15, 2004
Location: Science Lecture Hall 50

Session: Research Training Program: Session II

Chair: John Dorsey

138. 1:20 **DETERMINATION OF BACTERIAL AND POLLUTANT FLOWS IN COASTAL ESTUARIES OF SOUTHERN CALIFORNIA.** **S. Yanamadala** and J. Dorsey. Loyola Marymount University, Department of Natural Sciences, Los Angeles, CA, 90045.

139. 1:40 **ENVIRONMENTAL INFLUENCE ON THE CLONING RATES OF METRIDIUM SEA ANEMONES.** **Kevin McCully.** 28320 Coveridge Dr., Rancho Palos Verdes, CA, 90275.

140. 2:00 **MODELING THE DISTRIBUTION OF INVASIVE ARGENTINE ANTS IN THE CONTIGUOUS UNITED STATES: EFFECTS OF CLIMATIC FACTORS AND HUMAN HABITATION.** **G. Y. Williams.** Redondo Union High School, Redondo Beach, CA 90277.

141. 2:20 **THE EFFECT OF BODY SYMMETRY ON ATHLETIC ABILITY.** **Nicole Young.** Palos Verdes Peninsula High School.

142. 2:40 **MOTOR DEVELOPMENT IN CHICKEN EMBRYOS.** **Joanne Siu.** Alhambra High School. Mentor: Nina Bradley, USC Keck School of Medicine.

3:00 **BREAK**

143. 3:20 **QUANTUM YIELD STUDIES OF SINGLET OXYGEN PRODUCTION BY SQUARE PLANAR COMPLEXES.** **H. Fong, J. Tang, A. Tran**, and M. Selke. California State University, Los Angeles Department of Chemistry and Biochemistry, 5151 State University Drive, Los Angeles, CA 90032.

144. 3:40 **ACCESSING THE EFFECTS OF SLEEP DEPRIVATION IN A LONG LIVED *DROSOPHILA MELANOGASTER* LINE.** **Anum Sheikh.** California Institute of Technology, Benzer Lab, Department of Biology Pasadena, CA.

145. 4:00 **ACTIVITIES CHARACTERISTIC OF *DROSOPHILA* LONGEVITY MUTANTS *1101, 1130*, AND *2456*.** **Anna Lam.** Alhambra High School, Mentor: Dr. Horng-Dar Wang, California Institute of Technology.

4:30 **Presentation by students who went to National AAJAS Meeting and student Intel Science Contentants; Joon-Bok (James) Lee, Su Fey Ong, Ved Chirayeth, Eddie Smetak and Genevieve Williams. Meeting will occur in Alamitos Room, Student Union.**

ABSTRACTS

1. DON REISH'S ANNUAL MARINE POLLUTION LITERATURE REVIEW: FOUR DECADES OF MONITORING THE SCIENCE

A.J. Mearns. Hazardous Materials Response Division, National Oceanic and Atmospheric Administration, Seattle, WA 98115. P. N. Oshida, U.S. Environmental Protection Agency, Washington, D.C.

For over three decades Donald Reish has been senior author of an annual review of the marine pollution literature, published in Water Environment Research Journal. The focus of the annual review is on the effects of pollution on marine life. Co-authors include past graduate students and a variety of other colleagues. Each year Don identifies up to 300 papers, sorts them by major subjects (oil pollution, sewage effects, monitoring, tissue residues, toxicity testing, marine debris, book and conference reviews, etc), assigns co-authors to read and summarize the papers, and then collates the results into a story of each year's marine pollution literature. Several of us have been "on board" as co-authors for nearly 30 years, always eagerly awaiting our "winter holiday" package of 3 x 5 cards. Thousands of papers have been reviewed by this team, providing Don, co-authors, and readers with a broad overview of trends in marine pollution topics, issues and research and how it has changed over the years. When Don started the review, the effects of marine pollution were obvious to anyone who went into the field, the LC50 was the standard bioassay and most of the papers were from the US, Canada and western Europe. Today, authors from Asia, the Mediterranean, Eastern Europe, South America and Africa vie with North Americans and Brits in paper production. Molecular biology has taken a controversial but commanding role. The history of the effects of marine pollution may be well served by this entire collection.

2. VARIABILITY IN POLYCHAETES: REGENERATING RUBBER-BANDS?

K. Fauchald. Smithsonian Institution, National Museum of Natural History, Department of Zoology, MRC 0163 Washington DC, 20013-7012

Despite the widely shared opinion about variability, especially of size-related features, in polychaetes, a preliminary study of both long- and short-bodied species suggest strong limitations on intra-specific variability. Examples from eunicid and polynoid polychaetes show that species with a limited number of segments have defined distribution of most major features. Even species with relatively high, and more variable number of segments, show distinct size-dependent patterns in distribution of segmentally occurring features. Invoking regeneration to account for variability should be done only when there is independent evidence of regeneration, such as narrowed anterior or posterior ends.

3. RAPID RECOLONIZATION OF INFAUNAL BENTHOS AT A DEEP-SEA DISPOSAL SITE

James A. Blake. ENSR Marine & Coastal Center, 89 Water Street, Woods Hole, MA 02543

A deep ocean dredged-material disposal site (2700–3000 m) off San Francisco was designated in 1994. A benthic monitoring program was initiated in 1995. Until 2002, the benthic infaunal samples were archived, with only sediment profile images and chemistry samples analyzed. Analysis of all archived benthic samples is now underway. Results from 2002 demonstrate that despite seven years of dredged material disposal, the benthic infauna is rich and clearly zoned in the same manner established during baseline surveys (1990–1991). Fifteen samples from September 2002 yielded a total of 405 species, comparable to 458 species from 28 samples collected during the baseline period. Fifty species collected in 2002 were not recorded in 1990–1991. Approximately 67% of the species are new to science. Lower slope sites (2850–3136 m) were dominated by long, thin-bodied polychaetes such as *Prionospio delta, Levinsenia flava,* and *Cossura* spp. Stations from about 2450 to 2775 m included more robust polychaetes such as *Aricidea simplex* and *Chaetozone* sp.1. Density, species richness, and diversity were high and consistent with baseline conditions. Preliminary results from analysis of 1998 samples following periods of heavy dredged material disposal indicate that the fauna was heavily impacted. However, the fauna appears to rapidly recolonize target areas when disposal volumes are reduced. Stations on the boundary of the disposal site in 2002 exhibited a rich and diverse fauna, similar to reference sites.

4. SOFT-BOTTOM MEGABENTHIC INVERTEBRATE POPULATIONS AND ASSEMBLAGES OF THE SOUTHERN CALIFORNIA SHELF IN 1998

M. James Allen[1], Doug Diener[2], Erica T. Jarvis[1], Valerie Raco-Rands[1], Christina Thomas[3], Yvette Ralph[3], and Don Cadien.[4] [1]Southern California Coastal Water Research Project, Westminster, CA 92683; [2]MEC Analytical Systems, Inc., Carlsbad, CA 92008; [3]Orange County Sanitation District, Fountain Valley, CA 92728; [4]County Sanitation Districts of Los Angeles County, Whittier, CA 90601

Megabenthic (trawl-caught) soft-bottom invertebrate populations have been monitored locally in southern California for more than 30 years, but the populations and communities have not been described synoptically. This study describes the distribution and relative importance of dominant invertebrate species in regional synoptic survey of the southern California mainland shelf conducted in 1998. Invertebrates were collected by 7.6-m head rope semiballoon otter trawls from 314 stations in 1998 at depths of 5–200 m. Samples were collected on the shelf from 5–200 m from Point Conception, California, to the United States-Mexico International Border (including bays/harbors and islands). Species were identified, counted, and weighed. A total of 313 species of megabenthic invertebrates representing 132 families, 21 classes, and 9 phyla were collected in the survey. Mollusks, arthropods, and echinoderms were the most diverse phyla. White sea urchin (*Lytechinus pictus*), ridgeback rock shrimp (*Sicyonia ingentis*), and California sea cucumber (*Parastichopus californicus*) were among the most important species in occurrence, abundance, and biomass. Invertebrate abundance, biomass, and species richness is much lower on the coastal inner shelf (10–30 m) than in bays or in deeper shelf zones. Invertebrate assemblages were associated with bays/harbors, inner shelf, middle shelf (30–120 m), or outer shelf (120–200 m). Overall, invertebrate populations decreased in mean abundance, biomass, species richness, and diversity relative to 1994, and earlier. Although the distribution of important species generally remained the same between this survey and a previous survey in 1994, some species changed dramatically in importance, perhaps in response to the 1997–1998 El Niño.

6. ASSESSMENT OF COPPER EMISSIONS FROM RECREATIONAL VESSEL ANTIFOULING PAINTS IN SOUTHERN CALIFORNIA

Kenneth Schiff, Dario Diehl. Southern California Coastal Water Research Project, Westminster, CA 92683Aldis Valkirs, Computer Sciences Corp., San Diego, CA 92110

Trace metals, especially copper, are commonly occurring contaminants in harbors and marinas. One source of copper to these environs is copper-based antifouling coatings used on vessel hulls. The objective of this study was to measure dissolved copper contributions from recreational vessel antifouling coatings for both passive leaching and hull cleaning activities. To accomplish this goal, three coating formulations, including hard vinyl, modified epoxy and a biocide free bottom paint were applied on fiberglass panels and placed in a harbor environment. *In situ* measurements of passive leaching were made using a recirculating dome system. Monthly average flux rates of dissolved copper for the hard vinyl and modified epoxy coatings were 3.7 and 4.3 $\mu g/cm^2/day$, respectively, while flux rates for the biocide free coating was 0.2 $\mu g/cm^2/day$. The highest passive flux rates were measured initially after cleaning activities, rapidly decreasing to a baseline rate within 3 days, regardless of copper-based coating formulation. Hull cleaning activities generated between 8.6 and 3.8 μg dissolved copper/cm^2/event for the modified epoxy and hard vinyl coatings, respectively. Aggressive cleaning using an abrasive product doubled the copper emissions from the modified epoxy coating, but produced virtually no change in the much tougher hard vinyl coating. When compared on a mass basis, roughly 95% of copper is emitted during passive leaching compared to hull cleaning activities over a monthly time period for a typical 9.1 m power boat.

7. DISCUSSION OF MALDANID NEPHRIDIA, AND AN EMENDED DESCRIPTION OF THE GENUS *PETALOCLYMENE* (ANNELIDA: POLYCHAETA)

K.D. Green. MEC Analytical Systems, Inc.–Weston Solutions, Inc., 2433 Impala Drive, Carlsbad, CA 92008

Paired neprhridiopores occur on the dorsum, posterior to the notopodial setal fasicles in *Petaloclymene pacifica* (Green 1997). This dorsal orientation of nephridiopores has not been previously described for the family Maldanidae. The generic definition of *Petaloclymene* Augener 1918, and the description of *P. pacifica* are emended. Characteristics of nephridia are reviewed relative to their contribution towards the understanding of taxonomic relationships among maldanids.

8. BENTHIC POLYCHAETE COMMUNITIES AT THE MOUTH OF THE SAN FRANCISCO BAY

Dorothy Norris and Michael G. Kellogg. City and County of San Francisco, Public Utilities Commission

The City and County of San Francisco conducts regional environmental monitoring in the near shore waters of the Gulf of the Farallones (the region on the continental shelf extending about 40 kilometers west of the Golden Gate and bordered on the north and south by Point Reyes and Point San Pedro, respectively) to assess potential impacts on the receiving water environment from the presence of an ocean wastewater discharge. Samples are taken to characterize the physical and chemical properties of the sediments and to evaluate benthic infauna communities in the study area. Offshore monitoring is conducted annually in the fall when sediments are least disturbed and infaunal recruitment is highest.

Results of this monitoring program have demonstrated that benthic infauna communities in the study area are numerically dominated by polychaete species. Five years of data have allowed recognition of three main infauna communities correlated with sediment grain size. A coarse-grain community was dominated by the polychaetes *Hesionura coineaui difficilis* (Banse 1963) and *Heteropodarke heteromorpha* Hartmann-Schröder 1962. The sand bars surrounding the mouth of San Francisco Bay, with predominantly well-sorted fine sands, were numerically dominated by the polychaete *Spiophanes bombyx* (Claparède 1870) and also characterized by a higher proportion of crustaceans than the other infauna communities. A third community existed in areas beyond the sand bars where the sediments were predominantly very fine sands with a variable percentage of silt and clay. This latter community was numerically dominated by the polychaete *Spiophanes berkeleyorum* Pettibone 1962, and the bivalve *Tellina modesta* (Carpenter 1864) and was the most diverse of the communities in the study area. Five years of data analysis indicate consistently higher concentrations of organic and inorganic contaminants, and increased benthic infauna abundance in those areas with higher percentages of silt and clay. An examination of long-term trends in the benthic infauna data found that seasonality and oceanographic influences were major factors affecting the benthic community structure in the study area.

This paper will present the polychaete community components and their relationship to the sedimentary environment using both ordination and cluster analyses.

9. USE OF REGIONAL DATA TO EVALUATE AND DEVELOP SEDIMENT QUALITY GUIDELINES

S.M. Bay[1], D.E. Vidal[1], and P.L. Myre[2]. [1]Southern California Coastal Water Research Project, Westminster, CA, 92683; [2]Exa Data and Mapping Services, Port Townsend, WA, 98368

Many types of sediment quality guidelines (SQGs) are available for the interpretation of sediment chemistry. However, information describing the accuracy of the different SQGs for predicting sediment toxicity or benthic community degradation is limited, often resulting in controversy regarding which guideline is appropriate for use. One factor further complicating the decision is that site-specific or regional differences in habitat or contamination characteristics may affect the performance of SQGs, thus creating uncertainty regarding their suitability. The availability of synoptic sediment quality data from regional monitoring and other assessment programs provides the opportunity to evaluate SQG performance on a regional level and identify the best SQGs for specific applications. A dataset consisting of matched coastal southern California sediment chemistry and acute amphipod toxicity measurements for 1100 samples was developed using EMAP and other regional monitoring data, as well as dredge material characterization information. This dataset was used to evaluate the performance of six SQG approaches, including the effects range-median (ERM), consensus median effect concentration (MEC), equilibrium portioning for organics (EqP), apparent effects threshold (AET), and logistic regression model (LRM). Empirical approaches such as the ERM showed better performance than the EqP and AET. Comparisons with the NOAA Sedtox database indicated that regional differences in the southern California data influenced the performance of the SQGs. The southern California dataset was also used to identify optimized application thresholds for the SQGs and to develop regional guidelines that had improved performance.

10. DEVELOPING A WATER EFFECTS RATIO FOR AMMONIA IN FRESHWATERS OF LOS ANGELES

Jack Q. Word[1], David W. Moore[1], Ashli Cooper[2], and Mary Ann Irwin[1]. [1]MEC Analytical Systems, Inc.; [2]Larry Walker Associates

California state and federal water quality criteria have been set for ammonia, although the range of effects appear to vary under different water quality conditions such as water hardness, ionic strength (conductivity), total dissolved solids (TDS), and pH (Borgmann and Borgmann 1997; Ankley et al. 1995). Development of a water effects ratio (WER) is being used to generate data on bioavailability of ammonia relevant to the watercourses of Los Angeles County. A site specific objective (SSO) using a WER can then be used to qualify existing criteria to identify a threshold effect level which has been scientifically tested and validated for the specific waterbody of concern. Our laboratory studies investigated acute and chronic effects of ammonia exposure to the amphipod, *Hyalella azteca* to assist development of a WER for ammonia for two waterbodies of Los Angeles County (the Los Angeles and San Gabriel Rivers). A comprehensive series of toxicological testing was conducted during 4, 7, 14, 28, and 42-d tests with exposure concentrations ranging from < 1 to more than 250 mg/L total ammonia. Associated water quality parameters such as water hardness, TDS, alkalinity, sodium ($Na+$), potassium ($K+$), and total organic carbon (TOC) were carefully monitored and assessed as contributing factors. Results from the acute toxicity testing demonstrated a reduction in toxicity for ammonia-spiked river waters relative to the moderately hard laboratory water (MHLW) by a factor of >2; ammonia toxicity was also reduced by a factor of approximately 2-fold when both EC_{50} and EC_{20} responses were compared. Results from chronic testing indicated that spiked ammonia concentrations <25 mg/L in SGR water did not cause adverse effects on the survival, growth, and reproduction of H. azteca over a 42-d exposure. Hormesis, or improved survival and growth at low concentrations of ammonia, was observed in all exposure tests that utilized SGR water during chronic testing. Survival was greater at concentration >1 mg/L total ammonia with no influence on survival apparent at concentrations approaching 25 mg/L total ammonia. A preliminary WER was calculated from data generated from the acute bioassay series ranged from 2.5 to 4.9 for the EC50 determinations. Chronic testing indicated the WER threshold was above our highest test concentration, 25 mg/L.

11. LIFE HISTORY CHARACTERISTICS OF *TEREDO NAVALIS* AND *TEREDO BARTSCHI* IN THE VICINITY OF A WARM WATER DISCHARGE: A CASE FOR MONITORING GLOBAL WARMING THROUGH CHANGES IN GEOGRAPHICAL RANGES OF MARINE SPECIES

D.E. Morgan. Millstone Environmental Laboratory, Dominion Nuclear Connecticut, Inc., Waterford Connecticut 06385, USA

Distribution and life history data were collected from 1968 to 1995 for two species of marine woodboring mollusks in Connecticut coastal waters. *Teredo navalis* is a cosmopolitan, temperate shipworm native to Long Island Sound (LIS), while *Teredo bartschi* is a semi-tropical shipworm and is confined to sites affected by the undiluted discharge of the Millstone Nuclear Power Station (MNPS). *Teredo navalis* grows faster and releases nearly100 times more veligers than *T. bartschi.* Temperature increases of 3–4 °C and 10–12 °C increased growth about 1.3–1.4 and 1.8–2.1 times, respectively, when compared to ambient conditions. *Teredo navalis* and *T. bartschi* ceased releasing veligers as temperatures dropped below 16 °C, although *T. bartschi,* in contrast to *T. navalis,* does not shutdown brooding activity at winter water temperatures. *Teredo navalis* ceased releasing veligers above 27 °C, in contrast to *T. bartschi,* which continued to release veligers at the highest discharge temperatures

(33 °C). It appears that *T. bartschi* requires higher water temperatures (~22 °C) than are common to the deeper areas of LIS to complete its life history and is not able to survive winter water temperatures common in the shallower waters of LIS (<2 °C). Analysis of long-term trends (28-yr.) in seawater temperature for LIS waters indicates a 1.2–1.5 °C increase. If this warming trend continues, *T. bartschi* should eventually extend its range to LIS.

12. THE ANTHOZOAN FAUNA OF OIL PLATFORMS NEAR POINT CONCEPTION, CALIFORNIA

John C. Ljubenkov. Dancing Coyote Ranch, P.O. Box 781, Pauma Valley, CA 92061

Six oil production platforms in the Santa Barbara Channel and north of Pt. Conception were surveyed using ROV collected photographs and diver collected biological scrapings. Two legs of each platform were photographed from the bottom (ranging between 400 ft and 800 ft) to the intertidal zone and on two platforms (Harvest and Gail) scrapings were collected to about 75 ft. The assemblages were dominated by filter feeders that attach to hard substrate and all platforms had dense mussel beds. Anthozoans were a major group present in nearly every sample. *Metridium senile* was the most encountered anemone at all depths, but *M. farcimen* and *M. exilis* were also present. Other Anthozoan genera that occurred were *Anthopleura, ?Diadumene, Corynactis, Amphianthus, Balanophyllia, Coenocyathus, Desmophyllum, Paracyathus,* and unidentifiable zoanthids. No strong pattern of zones was apparent. Gorgonians were lacking compared to sewage outfall pipes at similar depths. This paper is part of a study that was funded by Minerals Management Service, Department of the Interior.

13. DEVELOPMENT OF AN EPIBENTHIC COMMUNITY (ANNELIDA: POLYCHAETA) IN AN ARTIFICIAL SUBSTRATUM AT VERACRUZ REEF SYSTEM, GULF OF MEXICO–AN EXPERIMENTAL APPROACH

V. Díaz-Castañeda (1) & de León-González, J.A. (2) Departamento de Ecología, CICESE, Km 107, Highway Tijuana-Ensenada, Apdo. Postal 2732, Ensenada, B.C., México; vidiaz@cicese.mx (2) Facultad de C. Biológicas, Universidad Autónoma de Nuevo León, Ap. Postal 5"F", San Nicolás de los Garza, Nuevo León, CP66451 México

Coral reefs are among the most complex and diverse biological communities. By providing substrata for sedentary organisms and food or shelter for mobile organisms, living corals create a rich series of habitats for a great diversity of species. This work contributes to the knowledge of the polychaete fauna in Veracruz Reef System. An experiment was designed to assess polychaete colonization patterns in three reefs subjected to different anthropogenic effects: Hornos, Pájaros and Blanca. Macrofauna colonization was studied analyzing 76 terracota plates; three sets of plates were immersed in spring 2001 and monitored for periods varying between 12 and 16 months. A total of 6,491 polychaetes were collected, belonging to 25 families and 127 species. Best represented families were Syllidae, Eunicidae, Nereididae, Cirratulidae, Terebellidae, Serpulidae and Sabellidae. Results confirm the importance and colonizing success of polychaetes, particularly syllids, serpulids and eunicids, in reef environments. Diversity (Shannon Index) varied between 0.80 and 3.70 and equitability (Pielou) between 0.40 and 0.97.

14. FECAL INDICATOR BACTERIA IN TIDAL WATERS OF THE BALLONA WETLANDS

John H. Dorsey. Loyola Marymount University, Department of Natural Science, North Hall, Los Angeles, CA, 90045

Densities of fecal indicator bacteria total Coliforms, *E. coli,* Enterococci) were measured within tidal channels of the Ballona Wetlands (Los Angeles County) to see if the wetlands act as a sink or source for these bacteria. Samples were collected on 10 days over a 1-yr period beginning February 2003 at four sites within the wetlands and one site in Ballona Creek opposite the west tide gate. Incoming flood and outgoing ebb tides were sampled during each sampling event at each station.

Water from Ballona Creek was the main source of indicator bacteria in the wetlands. Within the tidal channels, densities ranged from 10^3-10^4 cfu/100 ml for total coliforms, and an order of magnitude lower for *E. coli* and enterococci; densities increased an order of magnitude after two rain events. For each indicator bacteria, the ratio of flood:ebb density at each station was regressed with the tidal range for that event. Although values of R^2 were weak (ave = 0.2320, range = 0.0052–0.4588), the trend was for the ratio to decrease with increasing tidal range, suggesting that more bacteria enter the wetlands on flood tides from Ballona Creek during neap tide conditions, but during spring tides, the ebb flows have greater bacterial densities. High water during maximum tides could be dragging additional bacteria off the tidal channel banks, thus increasing densities in the water flowing back to Ballona Creek.

15. AN ICP-MS STUDY OF CD, ZN AND CU ACCUMULATION IN THE BODIES, CYTOSOL AND JAWS OF THE POLYCHAETE, *NEANTHES ARENACEODENTATA*

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The relative toxicities of Cu, Cd and Zn to the marine polychaete, *Neanthes arenaceodentata* have been assessed by exposing organisms for four weeks to free ion activities of metal varying from 10^{-7}M-10^{-12}M for Cd and Zn and 10^{-10}M-10^{-15}M for Cu. NTA or EDTA were used to buffer the free ion activities of the metals in the seawater. The toxicities decreased in the order Cu>>>Zn>/ = Cd with the "non-lethal" thresholds being approximately 10^{-10}M for Cu and 10^{-7}M for Zn and Cd. Tissue analyses for Zn and Cu by ICP-MS showed the concentration of these metals to be highly regulated. In contrast, a dose dependent increase in tissue Cd was observed which, in the worms exposed to Cd 10^{-7}M, was at least partially attributable to the induction of two major pools of Cd binding proteins that could be resolved by directly coupled ion exchange HPLC-ICP-MS. Correlation analyses showed positive ($p<0.001$) relationships between Mn, Fe and V in control tissues with additional relationships developing upon exposure to Cu, Zn and Cd. Laser ablation ICP-MS of the jaws from control worms showed a spatial gradient in the distribution of metals with Zn, Mn and Mg being the predominant elements at the tip, middle and basal regions respectively. Although exposure to Cd caused detectable increases in Cd throughout the jaw, no effect was noted with either Zn or Cu. It is concluded that while residue analyses of *Neanthes* may prove useful for determining Cd exposure, they are unsuitable for the assessment of Cu and Zn water quality.

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16. REPRODUCTIVE BEHAVIOR OF THE MALE *NEANTHES ARENACEODENTATA* (ANNELIDA: POLYCHAETA)

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Members of the polychaete family Nereididae reproduce in a variety of ways. *Neanthes arenaceodentata,* and its species complex of *N. acuminata* and *N. caudata,* is unusual in that following egg laying and fertilization within a mucoid tube, the female dies and the male incubates the developing embryos 21–25 days. At this time the juveniles, which had existed on its yolk for energy and growth, leave the male's tube and begin to feed. It was established in preliminary experiments that the male can successfully fertilize and incubate embryos from six successive matings. Female number seven laid eggs but were not fertilized. Both sexes died shortly thereafter. Therefore, under laboratory conditions of 20 ° C, the male can live over one year but the female only about 4–5 months. Sex pheromones attract the opposite sex to one another facilitating reproduction; same sex encounters result in fighting which may result in cannibalism. Surrogate males will successfully incubate developing embryos for the 21–25 day incubation period, but the number of juveniles emerging at the end of this time is reduced significantly. The working hypothesis in this study is that the number of emerging juveniles at the end of the incubation period is reduced with each successive reproduction. Experimental protocol was standardized. Worms used in this experiment were taken from the laboratory colony which was established from six worms collected from Los Angeles Harbor in 1964; it is estimated that the population has undergone nearly 200 generations in the laboratory. Worms were placed in individual petri dishes shortly after emerging from the male's tube to insure, especially young males, that they had not previously reproduced. Males initially weighed 60 ± 5 mg wet weight and were placed with females with developing eggs in her coelom and weighed 70 ± 10 mg wet weight. They were fed the green alga *Enteromorpha* weighing 260 ± 10 mg wet weight as needed, usually three times a week. The alga had been collected at one time previously from the field, frozen and thawed before use. At the time of writing this abstract, some males had successfully reproduced four times and have been placed with the fifth female. The data thus far generated does not support the working hypothesis.

17. THE GYPSUM RIDGE LOCAL FAUNA, AN EARLY PLEISTOCENE VERTEBRATE ASSEMBLAGE FROM TWENTYNINE PALMS, SAN BERNARDINO COUNTY, CALIFORNIA

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Paleontological collecting forays between 1997 and 2003 in the Gypsum Ridge Training Area of the Marine Corps Air Ground Combat Center (MCAGCC), Twentynine Palms, San Bernardino County have yielded a diverse early Pleistocene terrestrial vertebrate assemblage of early Irvingtonian age. Since its first documentation in 2001, the fauna has significantly increased in diversity. Paleomagnetic data collected through the fossiliferous section indicate that the entire sequence appears to be reversed and accumulated during the Matuyama Chron. Biostratigraphy provides the strongest evidence supporting an early Pleistocene age for this assemblage. The stratigraphic context of the fossiliferous sequence fifty-five feet in thickness suggests a prograding alluvial fan onto an alkali lake with internal drainage. The fauna contains the slug *Deroceras* sp., anurans, reptiles including snakes, lizards, and the tortoise *Hesperotesto,* shore birds and rails, and mammals including edentates, insectivores, rodents, lagomorphs, carnivores perissodactyls, artiodactyls and *Mammut.* The stage of evolution of the packrat *Paraneotoma* coincident with the joint occurrences of *Erethizon* sp., *Paramylodon harlani, Nothrotheriops texanus, Ondatra idahoensis* and *Sigmodon medius* support an age of between 2.0 to 1.7 Ma. The presence of *Repomys* n. sp. is a significant range extension for a taxon normally found in late Hemphillian and early Blancan faunas. Other rodents include *Eutamius* sp., *Perognathus* sp, cf. *Dipodomys,* and *Reithrodontomys* sp. Lagomorphs include *Hypolagus* cf. *furlongi, Sylvilagus* sp. and *Lepus* sp. The only carnivore is *Bassariscus* sp. *Sigmodon* is the by far the most abundant rodent suggesting a moist warm climate during the time of deposition.

18. A LATE PLEISTOCENE (RANCHOLABREAN) VERTEBRATE ASSEMBLAGE FROM OCEANSIDE, SAN DIEGO COUNTY, CALIFORNIA

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A late Pleistocene vertebrate assemblage was recovered during grading for the Wanis View Estates housing development along the San Luis Rey River, east of the city of Oceanside, northwest San Diego County, CA. Both macro-and microvertebrate fossils were recovered from rocks representing a transgressional sequence of lake muds and floodplain deposits that accumulated in response to rising sea level. These deposits range in elevation from 6 to 41 meters (15–135 feet) and are here tentatively correlated with the Guy Flemming marine terrace, dated at 345 ka. The underlying unit, previously mapped as the middle Eocene Santiago Formation, is here assigned to the Sespe/Vaquerous Formation based on lithology and the presence of micromammals of Arikareean (late Oligocene/early Miocene) age. A diverse assemblage of late Pleistocene fish, amphibians, reptiles, birds, and mammals were collected during excavation activities. The freshwater fish assemblage contains *Eucycogbius, Cottus, Mugil, Gasterosteus,* and *Gila*(or *Rhinichthys*) and is the most diverse for all southern California sites. Other lower vertebrates including the anurans *Bufo* and *Hyla,* and the pond turtle *Clemmys,* corroborate the sedimentological evidence for a lacustrine depositional environment. The mammalian fauna is represented by *Urocyon, Sylvilagus, Spermophilus, Thomomys, Perognathus, Reithrodontomys, Neotoma, Microtus, Equus, Tapirus, Bison, Mammut,* and *Mammuthus,* and is typical of other Rancholabrean faunas from Western North America.

19. PLEISTOCENE VERTEBRATES OF THE LOS ANGELES BASIN AND VICINITY (EXCLUSIVE OF RANCHO LA BREA): AN UPDATE

Sherri M. Gust. Cogstone Resource Management Inc.

Numerous Rancholabrean fossils have been recovered since Miller published on this subject in the early 1970s. Fossils recovered from projects in southern California are compared to one another and to the community represented at Rancho La Brea. Taxonomic representation, proportion of herbivore and carnivores, and selected summary measurements are presented illustrating both the similarities and differences.

20. A LARGE FOSSIL FLORA FROM THE PLEISTOCENE OLDER ALLUVIUM, TRIPLE M RANCH, CORONA, CALIFORNIA

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During excavations for construction of a housing development known as the Triple M Ranch near Corona in Riverside County, California, a collection of over 1000 fossil leaf impressions were salvaged from sediments of an unnamed Pleistocene unit mapped as "Older Alluvium". To mitigate the adverse impacts of project earth moving on these important paleontological resources, the fossil leaf specimens were submitted to a paleobotanist for identification and age and paleoenvironmental interpretations prior to their being accessioned into a public museum.

The Triple M Ranch Flora is low diversity, containing only about 16 taxa and including oaks, chaparral, dogwood, madrone, chinquapin, mountain mahogany, sycamore, aspen, sumac, willows, grasses, cattail, and 2-needled pines. Conspicuous by their absence are ferns and other conifers. This fossil leaf assemblage clearly represents a typical Southern California scrub oak chaparral community.

The presence of vegetation typical of the same area today suggests that the climate in which the vegetation grew was similar to the present Mediterranean climate—warm temperate to subtropical, with a long, hot and dry summer and a short, mild and wet winter. The depositional environment is interpreted as a shallow pond or lake and leaf remains were probably transported to the site either by rain-swollen streams during winter rains or during summer flash floods. Because the pond deposits are at the base of a fanglomerate shed during uplift of the Santa Ana Mountains, the flora possibly chronicles vegetation prior to and during the uplift.

21. DEPOSITIONAL HISTORY AND PALEOENVIRONMENT RECONSTRUCTION OF A MIOCENE MAMMAL AND BIRD TRACK SITE WITHIN BASIN FILL SEDIMENTS OF THE COPPER AND COFFIN CANYONS, DEATH VALLEY NATIONAL PARK, CALIFORNIA

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A sequence of conglomerate, clay, siltstone, evaporates and basalt flows exposed within Copper and Coffin Canyons, Death Valley National Park represent over 3000 meters of basin fill sediments deposited in a tectonic setting involving major crustal extension, faulting, basin formation, deposition, and subsequent uplift. The Copper and Coffin Canyon basin fill deposits are significant because they preserve the richest, most diverse, Cenozoic vertebrate fossil track assemblage in North America and possibly the world. To date, thirty-six ichnospecies of cat, camel, horse, mastodon, and bird tracks have been identified from the lakeshore sediments of Copper and Coffin Canyons. These tracks represent a diverse fauna of large terrestial mammals and birds, many of which have no body counterparts in the fossil record. The Copper and Coffin Canyon basin fill deposits are part of a succession of middle Miocene through Pliocene basin fill deposits that define the Furnace Creek Basin and the northern portion of Death Valley Basin. Temporally and lithologically the Copper and Coffin Canyon basin fill deposits are part of this succession however, up to now, previous workers have overlooked them. Work is currently underway to: (1)reconstruct the conditions that attracted and were responsible for the preservation of the Copper and Coffin Canyon tracks; (2)determine why the tracks are so abundant within the Copper and Coffin Canyons and why similar lithologic deposits are void of tracks; and (3)acquire radiometric dates such that the Copper and Coffin Canyon basin fill deposits can be stratigraphically and biostratigraphically applied to the geologic time scale.

22. FOSSIL MARINE FISH FAUNA FROM A LATE PLEISTOCENE SITE ON MISSION BAY, SAN DIEGO COUNTY, CALIFORNIA

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Late Pleistocene shallow water marine molluscan faunas are well documented in the San Diego area. One of these molluscan sites situated above the northeast shore of present day Mission Bay has been called the "Railroad Cut Locality" (RCL). The RCL site was first collected by Stephens (1927) and later by Kern and others (1971). They reported 69 molluscan species and a single vertebrate, *Myliobatis californica.* Amino acid dates place this site at about 300,000 years. A 200-pound matrix sample from this site was water-sieved through 25 mesh-per-inch screens and the remaining concentrate was sorted with the aid of a binocular microscope, yielding bones, teeth, and otoliths of twelve species of marine bony fishes, and eight species of sharks and rays. The RCL fossil fish fauna is dominated by estuarine gobies, *Quietula y-cauda, Lepidogobius lepidus and Ilypnus gilberti,* that presently inhabit shallows of Mission Bay. But two other estuarine gobies, *Microgobius sp.,* which today lives in southern Baja California, and *Quietula guaymasiae,* that presently inhabits the northern and central Gulf of California, indicate that average ocean temperatures during this time in the Late Pleistocene may have been several degrees warmer than today. Also, the presence of at least 5 species of warm water mollusks, and southern fish species such as *Bairdiella icistia,* and *Rhizoprionodon longurio* argue for elevated ocean temperatures. The recovery of five species of estuarine gobies supports Kern and others' (1971) conclusion that the RCL locality sediments were deposited in waters 1 to 2 meters in depth.

23. RECENT SURVEY WORK NEAR EL GOLFO DE SANTA CLARA, SONORA MEXICO

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Middle Pleistocene Colorado River Delta deposits exposed in the upper Gulf of California have yielded a diverse vertebrate fauna and associated flora. Late Quaternary doming along the Cerro Prieto Fault has allowed extensive dissection of ancient deltaic sediments in western Sonora, revealing thick fluvial units from which Irvingtonian-aged fossils have been recovered.

A collaboration between the Reserva de la Biosphera—Alto Golfo de California y Delta del Rio Colorado (SEMARNAP), Arizona Western College and the George C. Page Museum have initiated a re-survey of the exposures. To date, over 900 mapped vertebrate fossil localities, representing over 55 species, are documented and numerous fossil work sites identified. A digital elevation model (DEM) is used as the base map for spacial and temporal analyses. The differentially corrected GPS data are placed in a GIS platform, allowing for a census of faunal distribution. In addition to the paleontologic survey, detailed GPS mapping of some major faults and related structures, along with measured sections, is being undertaken.

These field studies in the past ten years have added in excess of six thousand specimens to a relatively small sample of vertebrates collected between 1939 and 1985. Studies by several colleagues are in progress which involve several mammalian groups including rodents, carnivores, perissodactyls, and cervids. New records of vertebrate species from El Golfo de Santa Clara include unexpected taxa in North American faunas, along with a new species of sheep and antelope.

24. EARLY RECORDS OF EXTINCT *BISON* FROM SOUTHERN CALIFORNIA AND THE BEGINNING OF THE RANCHOLABREAN NORTH AMERICAN LAND MAMMAL AGE

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The Rancholabrean North American Land Mammal Age, named for the mammal assemblage from the Rancho La Brea asphalt deposits in Los Angeles, California, is characterized by the presence of the Eurasian immigrant genus *Bison* south of 55ºN latitude. The timing of the arrival of *Bison* in the coterminous United States has not been determined with any certainty, and so the beginning of the Rancholabrean has not been reliably established. Recent studies suggest a date younger than ~220,000 years before present, but estimates vary.

Land mammal ages are defined in faunal terms, and faunas do not manifest themselves across the entirety of a continent in a geologic instant. As a result, these ages are time-transgressive rather than synchronous. In the case of the Rancholabrean, this diachronous nature may be quantifiable due to the abundance of Pleistocene localities and the precision of radiometric dating techniques.

In southern California, reports of early records of Pleistocene *Bison* from the region are generally poorly supported. Early records of *Bison* from the Murrieta region in Riverside County, and from Lake Manix in the Mojave Desert, were based upon misidentified elements. Other early records of *Bison* from coastal southern California were recovered from sites with complex stratigraphy; these finds often lack reliable stratigraphic context. These examples emphasize the importance of both precise identifications and detailed contextual data when interpreting the age of fossils of extinct *Bison,* particularly in cases where those records may help define the beginning of the Rancholabrean, both regionally and continentally.

25. RALPH B. CLARK REGIONAL PARK: AN UNTAPPED TREASURE TROVE OF PLEISTOCENE FOSSILS

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Located along the western edge of the Coyote Hills in northern Orange County, Ralph B. Clark Regional Park contains a little-known, but significant cache of Pleistocene fossils. Vertebrate and invertebrate remains, both marine and terrestrial, have been found in the following strata: the San Pedro, Coyote Hills, and La Habra Formations. Successively, these rock units represent a local, regressive marine event during a time span of 1.4 million to 10,000 years b.p. The fossil collection is housed within the Interpretive Center, located at Clark Park. The collection consists primarily of fossils found within the park as well as recent additions from other Pleistocene localities along the Coyote Hills region.

26. SHOULD I STAY OR SHOULD I GONAD? SITE FIDELITY AND SEASONAL MOVEMENT PATTERNS OF CA SHEEPHEAD (*SEMICOSSYPUS PULCHER*)

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The California sheephead, *Semicossyphus pulcher* (Labridae), is a temperate, rocky-reef/kelp-bed fish that is sought by recreational and commercial fishermen. No-take marine reserves may be an effective management strategy that could protect stocks, but first, it is necessary to determine the movement patterns and site fidelity of this fish. We have used short-term acoustic tracking to determine home ranges of sheephead; however, this method was not sufficient to determine long-term stability of their home ranges or seasonal movements. Therefore, 16 additional adult sheephead were fitted with long-term (1 yr) transmitters and their presence and movement patterns in a no-take marine reserve were monitored by an automated acoustic receiver array. Short-term tracking has shown that sheephead revisit locations each day and had relatively small home ranges ($< 82{,}000\ m^2$). The long-term acoustic monitoring data confirms that these sheephead generally have a high degree of fidelity to the areas of the reserve, spending 92% of their days within the reserve area, with most fish utilizing a core area encompassing 2 to 3 monitors (<600 m linear distance). However, these fish showed some variability in area use between months, exhibiting periods of expansion in their range between December and March (non-spawning period), with fish visiting areas previously unutilized. Water temperature also appears to have a significant effect on activity and distance fish moved. In some cases these expanded movements resulted in the fish crossing the reserve boundary for an extended period or leaving the reserve permanently, potentially exposing the fish to capture.

27. THE FISH ASSEMBLAGES INSIDE AND OUTSIDE OF A MARINE RESERVE AT SANTA CATALINA ISLAND, CALIFORNIA

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The fish assemblage of the rocky reef kelp forest habitat of Santa Catalina Island, California was compared inside and outside of a marine reserve. Two sites inside and out of a marine reserve were sampled approximately quarterly using visual census on SCUBA at depths of six and 12 meters from October 2002 to February 2004. On each sampling date, divers swam a 2 m wide x 50 m long transect counting all conspicuous fishes within the $100m^2$ area and assigning each fish to one a five size classes (adult, sub-adult, juvenile, young of year or recruit). Twenty-three species from 14 families were observed on transects during this period. The assemblage was dominated by warm temperate and subtropical species including pomacentrids, gobiids, labrids and serranids. Species richness was similar at all sites however, the relative abundance of some species differed between reserve and non reserve sites. Densities of adult sheephead (*Semicossyphus pulcher*) and kelp bass (*Paralabrax clathratus*) were significantly higher inside the marine reserve. There were no strong seasonal patterns of abundance in the assemblage of fishes. Overall, these data indicate that a small marine reserve may effectively protects some recreationally important species from harvest and ultimately may lead to enhanced stocks of these fishes at non-reserve locations through larval export and/or adult emigration.

28. RECOMMENDATIONS FOR A RESERVE IN LA JOLLA BASED ON PATTERNS OF HABITAT, DIVERSITY, AND OCEANOGRAPHIC CLIMATE

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An extensive underwater survey of the La Jolla kelp forest was conducted during the spring and summer of 2002. The main purpose of the survey was to develop an extensive database on the resources and biological communities within hard-bottom habitats throughout La Jolla to help determine the effectiveness of the San Diego-La Jolla Ecological Reserve, which was established over thirty years ago, and to make recommendations for a more effective reserve if necessary. The Reserve protects the confluence of four different habitats: the extreme northern margin of the La Jolla Kelp Forest, a shallow boulder-reef habitat, the head of a submarine canyon, and a gently sloping sandy shelf. The Reserve is relatively small (533 acres) and was not designed to achieve specific goals. Based on patterns of habitat, diversity, and oceanographic climate, we recommend no changes to the existing Reserve and the establishment of a new reserve protecting the southern half of the La Jolla Kelp Forest.

28a. EFFECTS OF WARM WATER DISCHARGES FROM THE MORRO BAY POWER PLANT ON HARD BOTTOM BENTHIC COMMUNITY STRUCTURE: FOLLOW-UP STUDIES TO DR. W.J. NORTH'S 1967/68 SURVEYS

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Warm water effluent from the Morro Bay Power Plant (MBPP) is discharged through a constructed canal into Estero Bay, central California. Morro Rock is the only rocky habitat in the immediate vicinity. The thermal plume contacts the north side of Morro Rock, exposing the intertidal and subtidal benthic communities to increased water temperatures. The warm water has been influencing benthic algal and invertebrate composition in these communities for almost 50 years, since the MBPP began commercial operation in the early 1950s.

Dr. W.J. North did the first thermal investigation of the area in 1967/68. North found fewer species on the north side of Morro Rock that is directly exposed to the thermal plume compared to the west side that receives little or no temperature increases. We re-surveyed the same areas in 1999 and 2001. Although information is lacking on community changes over the intervening period between North's study and ours, the results from both studies are consistent in having detected differences in community composition with distance from the discharge. We were able to use indicator species (e.g., *Mazzaella flaccida, Laminaria setchellii*), as revealed in our thermal effects studies at the nearby Diablo Canyon Power Plant, to explain some of the community differences on Morro Rock being related to water temperature, and used indicator species to determine the spatial extent of thermal effects on Morro Rock.

The MBPP ceased operation in 2003. This now provides an opportunity to examine recovery, and an opportunity to validate our thermal effects evaluation based on the distribution of indicator species.

28b. GETTING READY FOR THE "BIG ONE": NATIONAL OILSPILL DRILL IN SOUTHERN CALIFORNIA AND ATTEMPTS TO REDUCE NEARSHORE IMPACTS USING DISPERSANTS.

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On April 20–23, 2004, over two thousand people from a variety of agencies and the oil industry conducted a major Spill of National Significance (SONS) oil spill drill in Southern California. The drill scenario involved a tanker releasing several million gallons of Arabian crude oil in San Pedro Bay, followed shortly by a second incident off Point Loma, spilling several hundred thousand gallons of heavy fuel oil. Command posts, populated by federal, state and industry responders, were established at Terminal Island and in San Diego. Networks were set up to communicate with Sacramento and Washington DC. Within 24 hours, shorelines of Orange County (Huntington Beach to Dana Point) were about to be impacted by several million gallons of emulsifying crude oil. Industry skimmers and boom teams were deployed within hours. Local agencies were notified and beaches and fisheries closed down. State and federal agencies sought and received approval to apply dispersants from aircraft, shoreline and damage assessment teams were set up and deployed to survey and recommend clean up actions and criteria, and wildlife recovery teams mobilized facilities to deal with thousands of oiled birds. A special issue was approval and use of chemical dispersants to reduce impacts of floating oil to birds, wildlife and shorelines. NOAA's HazMat team provided trajectory forecasts for both floating oil and dispersed oil in the water column. The dispersed oil plumes moved nearshore, exposing kelp beds, reefs and nearshore subtidal marine life to dispersed oil at concentrations in the range of 0.5 to 10 parts per million for up to 24 hours. It was concluded that such exposure would not affect kelp, seagrass, adult fish or adult crustaceans, but could injure reproductive products and plankton. The drill was successful in overwhelming agency resources and initiating important new discussion about response preparedness and tradeoffs.

29. STATUS OF THE KELP BEDS OF ORANGE AND SAN DIEGO COUNTIES IN 2002 WITH A REVIEW OF THEIR STATUS THROUGH 2003

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In the previous two and one half decades, kelp beds in Orange and San Diego Counties have been repeatedly affected by a continuing series of El Ninos. Although the latest El Nino was in 2003, its effects were exceedingly mild on the extant canopies of the region. A cooling trend interrupted by one relatively mild El Nino has resulted in continued growth of most of the canopies along this portion of the coastline. However, during the El Nino of 1997–1998, kelp beds were decimated in San Diego and Orange Counties leaving kelp resources at their lowest ebb recorded during the century. In 1999, we began a slow but steady march back from that brink to a substantial recovery of the resource. Although all the beds lost biomass, not all of the beds recovered as rapidly or completely. By looking at the long-term record on a regional basis, we explore herein the reasons for these incongruities. A database to assess these changes was available as quarterly kelp bed aerial surveys are a requirement, since 1983, of discharge permits into the offshore waters under the jurisdiction of the San Diego Regional Water Quality Control Board and because the late-Dr. Wheeler North of Caltechs' Kerckhoff Marine Laboratory had been collecting aerial photos of these beds since 1967. By means of aerial infrared photography, the 24 distinct beds that occur offshore of Orange and San Diego Counties were recorded as best as possible at the maximum areal extent of any canopies during the year. Although the intention was that a synoptic survey of the beds would allow a determination of the potential effects of waste water (both heated effluent and sanitary) on the kelp beds, insight is provided, through the medium of aerial photographs, on the kelp beds response to and the aftermath of the this El Niño.

Based on these data, a synopsis of the health of each of the kelp beds and the effects of these environmental perturbations, as it compares with the other kelp beds in the region, can be determined. Although it is not possible to determine the cause of a decline or decrease in a single kelp bed by aerial photographs, it does determine whether the bed in question is responding to an area wide event, or if it is atypical of the beds in the region. Atypical beds can then be categorized according to their distance from other beds, substrate depth, and potential biological factors. Looking at these factors can then offer some insight as to the cause and effect of the differences noted.

30. THE SAN CLEMENTE ARTIFICIAL REEF–EXPERIMENTAL PHASE KELP WRACK STUDY RESULTS

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The San Clemente beach is being monitored to determine if reef material and/or kelp wrack from the adjacent 22.4-acre San Clemente Kelp Experimental Artificial Reef (SCAR) is having an affect on beach conditions. This study is directed by the California Coastal Commission and is conducted by Southern California Edison. Two materials, broken concrete and quarry rock, and three bottom coverage densities, 17%, 34%, and 67%, are being tested on SCAR, offshore of the San Clemente beach, to discern the best design for the build-out of this kelp mitigation reef to 150 acres. The experimental reef was built in September 1999 and is in about 45 feet of water, ½ mile off the beach and spans about 2.5 miles of beach frontage. In the project's environmental review phase, concern was raised about the potential of reef material washing up on the beach, and kelp wrack increasing substantially. To date, the routine observations of the San Clemente beaches show no artificial reef material, either quarry rock or concrete, is washing onto the beach. Further, kelp wrack from the artificial reef does not appear to be making a substantial contribution to the limited amount of seaweed wrack that periodically appears on the beach. The program scientists are now awaiting some significant storms, wave events, and/or El Niño-type events, as the study period, 1999–2004, has included only limited stormy conditions. The assumption is that "sea-change"-type (episodic/catastrophic) events drive the system, and the experimental study period has yet to encounter these events.

31. GLOBAL MONITORING OF TEMPERATE REEF ALGAL COMMUNITIES

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Global climate change has the potential to dramatically alter the distributions of algal populations in temperate reef communities. The detection of these broad scale fluctuations, however, will require discriminating them from the frequent local scale fluctuations that occur in these populations. We are beginning a NASA sponsored project to create a global scale monitoring program of kelp populations based on a variety of satellite imagery. Earth Satellite Corporation has produced a world-wide mosaic of cloud-free LandSat 7 ETM+ imagesfor the year 2000. We will be processing the coastal images from this series to quantify the surface area of nearshore kelp canopies. The ETM+ imagery has a spatial resolution of 30 m in the infrared channel and 15 m in a panchromatic channel that extends into the near-infrared. We will be testing the efficiency of this imagery, as well as higher spatial resolution imagery from the ASTER instrument, for quantifying the population size of kelp populations. A series of validation studies will be conducted in Baja California and Chile to correlate the satellite data with diver collected population data. We will also analyze AVHRR satellite imagery on a global scale to quantify sea surface temperature distributions and anomaly patterns that can be compared with changes in kelp canopy abundances. An interactive web site with internet map server capabilities, analogous to the web sites monitoring change in tropical coral reef communities, will be developed to help provide a global view of kelp population changes.

32. EFFECTS OF BEACH REPLENISHMENT ACTIVITIES ON NEARSHORE MARINE HABITATS

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Over the past two decades, San Diego's shoreline has experienced chronic and continuing erosion. In an effort to restore many of the beaches, SANDAG in 2001 implemented the Regional Beach Sand Project which dredged just over two million cubic yards of sand from four offshore borrow sites and replenished 12 beaches along the coast of San Diego County. Concern from resource agencies and commercial fishermen regarding the potential for the sand placed on the beaches to impact nearby reefs promulgated monitoring of rocky intertidal, shallow subtidal, and kelp forest habitats in the vicinity of select receiver sites. Since implementation, there has been varied response and this presentation will discuss 3 years of shallow subtidal and beach profile monitoring data regarding coastal processes and its effect on nearshore reefs.

33. SIZE-DEPENDENT PREDATION ON TWO TEMPERATE-REEF FISHES: CAN CONFLICTING RESULTS FROM FIELD AND LAB STUDIES BE RECONCILED?

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Mortality rates of fishes generally decline with increasing body size. This pattern is widely believed to be caused by size-dependent predation, that is, smaller fish suffer higher rates of predation than larger fish. There have been, however, relatively few tests for size-dependent predation in marine fishes, and most of these have been made in the lab. It is unclear how well the results of such lab studies can be extrapolated to nature. I used both lab and field experiments to test for size-dependent predation on two abundant southern California reef fishes, the bluebanded goby (*Lythrypnus dalli*) and the blackeye goby (*Rhinogobiops nicholsii*). Lab experiments generally revealed size-dependent predation, but field experiments did not. I speculate that the wide range of sizes of predators present in the field causes all sizes of the gobies I studied to experience roughly equal risk of being eaten. Since a full spectrum of predators is seldom maintained in the lab, I suggest that evidence of size-dependent predation generated by lab study should be viewed with caution and I urge researchers to use field experiments in future studies on this topic.

34. BIOGEOGRAPHY OF THE NEARSHORE ROCKY-REEF FISHES AT THE SOUTHERN AND BAJA CALIFORNIA ISLANDS

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Between June 2000 and August 2002, the nearshore rocky-reef fishes of eight southern and Baja California islands were quantitatively surveyed. The islands surveyed were: Santa Cruz, San Nicolas, Santa Barbara, Santa Catalina, San Clemente, North Coronado, San Martin and San Benito. These islands span the latitudinal range of offshore islands within the San Diegan marine province. This regional scale approach provided not only the first quantitative description of rocky-reef fishes at five of these islands, but also allowed comparisons with known biogeographic patterns to be made. Here we discuss the distribution and abundance of 84 conspicuous rocky-reef fishes from 35 families. In general, the richness, diversity and composition of fish assemblages at these islands were found to reflect previously described biogeographic processes. The rocky reef fish assemblages of all the islands in the survey were found to be significantly distinctive form each other. Phenetic analyses revealed two clusters. San Clemente, Santa Catalina and North Coronado clustered as a warm water assemblage in the middle of the San Diegan Province. The remaining islands grouped together as a cold water assemblage, despite the geographically disjunct position of the islands within this cluster. The relatedness of islands was independent of distance. Examination of the most common fish species at all islands revealed that while some conformed to the north-south trending density distributions predicted by previous investigators, the distribution of others could not be explained by latitude or temperature regimes. No single pattern explained the density of fishes at all islands.

35. RECRUITMENT OF REEF FISHES IN THE SANTA BARBARA CHANNEL

J.E. Caselle. Marine Science Institute and PISCO, University of CA, Santa Barbara, CA 93106

I monitored recruitment of reef fishes to SMURFs (Standardized Monitoring Unit for Recruitment of FIshes) throughout the Santa Barbara Channel since 2000. There were strong interannual patterns. Rockfishes (*Sebastes* spp) have increased in abundance since 2000 while kelp bass (*Paralabrax clathratus*) have decreased over the same period. Despite year to year variation in abundance, spatial patterns around the Northern Channel Islands were remarkably consistent for most taxa. Preliminary analyses of oceanographic conditions (temperature and current patterns) give some insight into the causes of the observed spatial and temporal patterns.

36. TEMPORAL PATTERNS IN THE SETTLEMENT OF CRYPTIC REEF FISH

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The settlement of reef-associated temperate fishes was monitored during the summer and fall of 2002 and 2003 at King Harbor, Redondo Beach, California. King Harbor is a man made harbor composed of rock reef and sand habitats. A total of eight settlement traps were anchored on the bottom at depths between 2 and 7 meters to provide a standardized form of structural shelter for settling larvae. During the study period divers conducted weekly and bi-weekly retrievals of these traps and all larval fish collected within the traps were preserved for identification and analysis. A total of 126 "new settlers" were collected during the months of July and August 2002 and 254 "new settlers" were collected during the same months of the 2003 season. Throughout the study four different species dominated the collections; *Gobiesox rhessodon, Paraclinus integripinnis, Hypsoblennius jenkinsi, Rus-*

carius creaseri. Settlement pulses were then compared to physical anomalies such as moon phase, sea surface temperature, and sub-surface temperature. The influx of new settlers was positively correlated, on a daily basis, with abrupt changes in temperature (ΔT; $r = 0.48$, $p = 0.003$). Preliminary results indicate that the majority of these reef-fish settlers are being transported inshore by processes that, in turn, also cause large temperature fluctuations in the water near the bottom. In this case, the observed temperature fluctuations were consistent with the occurrence of tidal bores.

37. LARGE AND SMALL SPATIAL VARIATION IN CRYPTIC REEF FISH ASSEMBLAGES

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Two reefs of differing depths within King Harbor, Redondo Beach, California, were sampled from January 2000 to September 2002. Fishes were collected from random 1 m^2 replicates using quinaldine. Multiple microhabitat characteristics were noted for each meter-square plot for small spatial variation analysis. Collections were also made during 2002 at Palos Verdes Peninsula and at two sites on Catalina Island (Salta Verde and Hen Rock) to address questions of large-scale spatial variation. Fourteen species were collected in King Harbor and the top 5 species accounted for 98% of the total numerical density and 95% of the total biomass density. The overall H′ diversity was low (0.42) due to the dominance of *Paraclinus integripinnis.* Species richness, H′ diversity, number of individuals and biomass were all greatest in the summer and early fall. Canonical correlation analysis of the microhabitat data showed that different species of cryptic fishes show a preference for particular types of algae and depth. Spatial variation was also seen on a large scale. Four of the 7 species collected at the Palos Verdes site were cottids indicating a cold water assemblage. Five species were collected at Salta Verde and only 3 at Hen Rock, but both sites were predominately composed of gobies.

38. RECENT DEVELOPMENTS IN AUTOMATIC CALIBRATION AND APPLICATION TO HYDROLOGIC MODELING

Terri S. Hogue. Department of Civil and Environmental Engineering, University of California-Los Angeles

Computer-based hydrologic models have become increasingly complex and are being utilized for numerous hydrologic tasks, including real-time forecasting of pending flood events, urban planning of design storms, and monitoring of water quality runoff, among others. The majority of these models consist of a lumped, conceptual description of the watershed, designed to represent the hydrology of the basin, with numerous parameters that must be estimated. These models are then applied to various climatic and hydrologic regimes and must be "adjusted or calibrated" to fit local hydrologic observations. Once an appropriate model is chosen, the usefulness of the model is highly dependent on the quality of the calibration and how well the model can simulate the desired fluxes or outputs (e.g., streamflow). Most models have been calibrated via the traditional approach, where an "expert" hydrologist with knowledge of the model and watershed system uses a trial-and-error procedure to adjust model parameters while visually inspecting the model simulations as compared to the observed streamflow. Due to the tedious and time-consuming nature of the manual calibration process, researchers in the 1960s began exploring methods that could speed up the calibration process and make it less subjective. Automatic calibration methods help in this regard by utilizing the speed and power of modern computer technology, while being fairly easy to implement and objective to analyze. A brief description of some of these automated technologies, along with their application to the operational hydrologic modeling system of the National Weather Service, will be presented.

39. MODELING WATER AND NUTRIENT EXPORT FROM COASTAL WATERSHEDS IN SOUTHERN CALIFORNIA

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Streamflow (water and associated constituents) from coastal watersheds affects the physical and chemical regime of nearshore marine and estuarine waters. As part of the Santa Barbara Channel–Long Term Ecologic Research Project, our goal is to quantify the terrestrial export of streamflow, nutrients and sediments from southern California's coastal watersheds. The primary component of this

effort is the spatial and temporal distribution of streamflow from the coastal watersheds (approximately 100) draining the Santa Ynez Mountains along the southern coast of Santa Barbara County California. We use a generalized watershed-scale rainfall-runoff model (HEC-HMS), calibrated and then verified against local hydrometric records, to derive streamflow time series for each watershed for three water years: 2001–2003, encompassing a both wet (2001/2003) and dry years (2002). The benefit of quantifying time series streamflow from each watershed is that they can be combined with regional relationships between land use, streamflow measures and nutrient export to approximately either annual or event nutrient export to a continuous coastal line. Using this approach, various land use and climate change scenarios can be developed and used to investigate their potential impacts on the export of water and nutrients to the nearshore environment.

40. NUTRIENT MANAGEMENT IN THE SAN JACINTO WATERSHED, CALIFORNIA

Rick Whetsel, Mark Norton. Santa Ana Watershed Project Authority, Riverside, CA. Andrew Parker, **Stephen Carter**. Tetra Tech, Inc., Fairfax, Virginia. Hope Smythe, Xinyu Li, Santa Ana Regional Water Quality Control Board, Riverside, CA

The Santa Ana Watershed Protection Authority is coordinating a watershed assessment and modeling study to support development of TMDLs for Lake Elsinore and Canyon Lake, as well as development of a nutrient management plan for the San Jacinto Watershed. Both lakes have exhibited eutrophic conditions in recent years that have triggered periodic fish kills. The effort has involved development and application of a watershed and lake modeling system that evaluates nutrient sources and transport under a range of hydrologic regimes.

EPA's Loading Simulation Program in C++ (LSPC) was used to simulate watershed processes, including hydrology, pollutant accumulation and washoff, and flow and pollutant transport in the streams and headwater lakes. LSPC was calibrated and validated for hydrology and nutrient loading at multiple locations. A simplified one-dimensional Environmental Fluid Dynamics Code (EFDC) model was developed to simulate nutrient loading impacts on Canyon Lake and transport to the downstream lake, Lake Elsinore. EFDC is capable of simulating hydrodynamics, salinity, temperature, suspended sediment, water quality, and the fate of toxic materials. It was successfully calibrated to available hydrodynamic and water quality data for a multi-year period covering mean, dry, and wet years.

Various alternative loading scenarios have been simulated with the LSPC and EFDC models, in order to test the sensitivity of various nutrient source loadings to lake water quality response. The comprehensive modeling system, composed of both the LSPC and EFDC models, provides the basis for making future management decisions in the watershed.

41. HYDRODYNAMIC MODELING OF FECAL INDICATOR BACTERIA IN TALBERT MARSH BASED ON LOADS FROM URBAN RUNOFF, BIRD FECES, AND RESUSPENDED SEDIMENTS

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Talbert Marsh in Huntington Beach, California is an estuarine, intertidal wetland where enteric bacteria concentrations chronically exceed State recreational water contact standards. It has been reported that during dry-weather periods Talbert Marsh is a net generator of enterococcus bacteria, contributing fecal pollution to coastal waters at Huntington Beach. Hydrodynamic modeling was conducted to study the extent to which loading of total coliform, *E. coli,* and enterococci by urban runoff, bird feces, and/or resuspended sediments control surface water concentrations in the marsh. In this presentation, the modeling approach adopted for this study will be described, an assessment of the model's ability to accurately predict fecal indicator bacteria will be presented, and the implications of the model predictions, in terms of the factors driving water column concentrations of enteric bacteria, are discussed.

42. DYE DISPERSION IN THE SURF ZONE: MEASUREMENTS AND SIMPLE MODELS

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To examine the spatial and temporal effect of low-volume landbased runoff on beach contamination, batches of dye were released at the shoreline at 3 beaches in Santa Monica Canyon in 2000 (Malibu Creek, Santa Monica Canyon and Pico Kenter drain). Dye concentration was measured at the shoreline 25m, 50m and 100m alongshore from dye release point for up to 40 minutes after dye release. The shoreline concentration time series reveal distinct characteristics in dye plume dispersion, the potential causes for which are investigated using a series of simple models to simulate shoreline concentration time series for an idealized surf zone. Favorable qualitative and quantitative comparison of measured and simulated time series suggest sheared alongshore currents and rip currents play key roles in generating the observed.

43. SPATIAL AND TEMPORAL VARIATION IN THE TISSUE HALIDE CONTENT OF THE COASTAL SALT MARSH HALOPHYTE, *SALICORNIA VIRGINICA*

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Coastal salt marshes are home to several different species of salt tolerant vascular plants called halophytes. One dominant species found in southern California is *Salicornia virginica.* I measured the amount of chloride, bromide and iodide in *S. virginica* tissue from three different sites, each located at different elevations in relation to tidal flux. This is the first report of values of the three halides from a California salt marsh species. Tissue samples were taken once a month for 13 months and analyzed for halides using a specific ion electrode based method (Grans analysis of potentiometric titration). Mean concentration (g dwt^{-1} ± S. D.) of chloride ranged from 11.2 ± 0.4 to 43.3 ± 8.0 %, bromide from 0.27 ± 0.02 to 1.84 ± 0.39 %, and iodide from 3.0 ± 2.1 to $1.2 \times 10^4 \pm 3.8 \times 10^3$ ppm. Results indicate significant differences, ($p < 0.0001$), in mean concentration among months and a significant interaction ($p < 0.0001$) between month and elevation for all three halides. The mean concentration of chloride was greater than values reported for other species of *Salicornia.* Several monthly values for iodide were extremely high but dropped precipitously thereafter. Very few environmental factors appeared to correlate with changes in halide tissue values. The mean tissue halide (wt/wt) ratios from all three elevations for the sampling period were 190 Cl^-:3.18 Br^-:1.0 I^- compared to a seawater ratio of 1.5×10^6 Cl^-:5200 Br^-:1.0 I^-. These results are discussed in terms of halide bioavailability and selective uptake.

44. EFFECTS OF DISPERSAL ON LOCAL DISTRIBUTION OF THE GRANITE SPINY LIZARD, *SCELOPORUS ORCUTTI*

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Dispersal of individuals from their natal site occurs for various reasons, including, avoidance of inbreeding and competition between closely related individuals. Distribution of individuals within a population is, therefore, determined by dispersal of different sex and age categories. In long lived, late maturing lizards, dispersal of individuals may occur at various times. *Sceloporus orcutti,* the granite spiny lizard, is a primarily rock dwelling lizard that is non-territorial, but occupies distinct home ranges and reaches sexual maturity at 3 years of age. Based on snout-vent length individual lizards are placed into one of three age categories (juvenile, immature, adult). To examine the pattern of dispersal of sexually immature individuals in *S. orcutti,* I used mark-recapture methods in a population on Lake Mathews Reserve, Riverside County, CA. To investigate local distribution of *S. orcutti* I mapped home ranges for 11 adults and basking sites for an additional 36 lizards. I also obtained DNA samples for genotyping and parentage analysis; however, I found little to no allelic variability which prevented parentage analysis. Results from captures and sightings indicate that *S. orcutti* are dispersing as immatures. I found juveniles clustered on the same rock outcropping, while most immature lizards were solitary. Due to the lack of genetic variability further field observation during the spring of 2004 of previously marked individuals will be used to add insight to dispersal patterns in *S. orcutti.*

45. GEOLOGY AND PETROLOGY OF A MIOCENE DACITE DIKE SWARM AND COGENETIC VOLCANIC ROCKS, LITTLE CHUCKWALLA MOUNTAINS, CALIFORNIA

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The Little Chuckwalla volcanic field comprises 1.5 kilometers of lava and pyroclastic flows ranging from basalt to rhyolite. The Little Chuckwalla field and others like it attest to explosive volcanism that was widespread during the early Miocene when the Farallon plate was being subducted beneath western North America. The stratigraphy of the Little Chuckwalla field and swarms of cross-cutting feeder dikes are entirely exposed thanks to late Miocene tilting of approximately 30° toward the southeast. The excellent exposure presents the relatively rare opportunity to study the cogenetic plumbing and erupted deposits of a subduction-related volcanic system. One prominent dike swarm comprises porphyritic dacite with uniquely high abundances of large blocky plagioclase phenocrysts. This dike swarm probably fed petrographically similar dacite lava and pyroclastic flows that are abundant in the upper half of the volcanic pile. The largest dike, up to 100 meters wide and exposed for over 3 km along strike, feeds into a thick, laterally extensive stack of dacite flows. Samples collected from various paleodepths in the dike and from the cogenetic flows are being analyzed to provide input for models of magmatic flow, thermal history, and differentiation during active volcanism.

47. JOINT DYNAMICS OF THE EQUINE FORELIMB DURING JUMPING

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During jumping, a horse (*Equus caballus*) must produce enough power to clear the obstacle using fore- and hind limbs. To investigate the forelimb during jumping, ground reaction forces (1000 Hz) and digital video (250 Hz) were recorded while three horses jumped an obstacle of 0.76m. Inverse dynamic analysis was used to determine the joint moment, power and work generated during stance phase of takeoff stride for the shoulder, elbow, carpus, metacarpophalangeal (MCP), and distal interphalangeal (DIP). The shoulder produced a net flexor moment early in stance and an extensor moment the remainder of stance (peaks: −1.2 Nm/kg, 9% stance, 1.9 Nm/kg, 73% stance). The elbow and MCP joints produced extensor moments with peak values of 2.0 Nm/kg at 50% and 1.6 Nm/kg at 62 % of stance. The average peak negative and positive powers were produced at 23% and 75% of stance (-7.6 & 9.5 W/kg). Total work done by the forelimb was found to be 0.29 J/kg, with 0.25 J/kg produced by the elbow. The shoulder and MCP joints produced a minor amount of positive work. Negative work was produced by the DIP (–0.074 J/kg) and no net work was produced at the carpus. Of the work done by the forelimb while jumping, it appears that the elbow joint makes the greatest contribution. Supported by NIH # S06 GM53933 to DFH & SJW.

48. SUMMERTIME DISTRIBUTION OF THREE SPECIES OF ATHERINOPSID FISHES IN EAST-CENTRAL SAN FRANCISCO BAY

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Nighttime sampling with neuston nets and daytime sampling with purse seines and beach seines were used, principally in June and July, to describe the distribution of larval and juvenile silversides (family Atherinopsidae) and other epipelagic fishes in the vicinity of a least tern (*Sterna antillarum*) breeding colony at Alameda Point in eastern central San Francisco Bay. All nets had 1.6-mm, knotless mesh. Three species of silverside, topsmelt *Atherinops affinis,* jacksmelt *Atherinopsis californiensis,* and California grunion *Leuresthes tenuis,* were captured. Larvae of all three silversides were taken in shallow intertidal areas, including a newly created beach in Middle Harbor, Oakland. Small ($\leq$ 50 mm) juvenile silversides were relatively abundant in protected sub-embayments, but captured in low abundance in waters >5 m deep or >300 m from shore. Larger (>50 mm) jacksmelt and grunion, and to a lesser degree, topsmelt occurred in moderate abundance farther from shore on the warm (approximately 19°C) shoal (< 8 m deep) south of Alameda Island, but jacksmelt was the only silverside species common in deeper, cooler (<18° C), and more exposed waters. Purse seine catches of silversides and other species decreased after about 0900 or 1000 hrs PDT, possibly due to vertical migration. Because the average time of day of purse seine sets was 1020, and varied by about 1 hr among stations, we believe that the neuston data are the more accurate descriptor of offshore abundance patterns for silversides in this 2003 data set.

49. STANDARD AND ROUTINE METABOLISM OF KELP BASS *PARALABRAX CLATHRATUS*

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Kelp bass (*Paralabrax clathratus*) are common inhabitants of the kelp bed community. As top-level predators, kelp bass feed on a variety of organisms such as squid, octopi, crabs, shrimps and other fishes, and thus play an important role in the local food web. By knowing the minimum energy requirements of a fish such as the kelp bass, it is possible to determine the minimum needed prey consumption and the subsequent impact of this consumption on the prey population. One method used to quantify trophic interactions is through the use of energy budgets, which represent how fish allocate ingested energy. The goals of this study were to measure routine and standard metabolism of the kelp bass, and incorporate these data into an energy budget. Metabolism was determined by measuring the oxygen consumption of the fish in a static respirometer. Oxygen consumption data was then converted to metabolic rates. To date, I have completed 24-hour runs on a total of 16 fish, ranging in size from 115–500 g (16–28cm S.L.), and 6-hour runs on 2 kelp bass recruits (3g). Oxygen consumption rates for kelp bass (52–220 mg O_2 kg^{-1} hr^{-1}) are comparable to other studies. The mass specific equation for these fish is $y = 258.7x^{-0.2619}$. Lab measurements of growth are underway, and these data combined with metabolic data and waste data from literature will be used to construct an energy budget.

50. MASS SIZE DISTRIBUTIONS AND DRY DEPOSITION FLUXES OF TRACE METALS MEASURED IN THE LOS ANGELES AIR BASIN

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Size segregated air concentrations and dry deposition fluxes of trace metals were measured directly in the Los Angeles Air Basin using a Noll Rotary Impactor (NRI) and deposition plates with aerodynamic surrogate surfaces. Fluxes were also estimated indirectly from the concentration measurements using theoretical expressions for the deposition velocity. The fluxes of Cu, Pb, and Zn in urban areas (annual mean of 22.46, 18.98, and 131.98 $\mu g/m^2$.day) were substantially higher than in non-urban area (annual mean of 4.07, 1.58, 17.10 $\mu g/m^2$.day). The use of deposition plate for direct flux measurement was found to agree well with those indirect flux estimations using calculated deposition velocities. The average dry deposition velocities for coarse particle size fraction were 0.44 ± 0.01 cm/sec for range of particle diameter 6–11 μm, and up to 12 ± 0.1 cm/sec for particle diameter 29–60 μm. Although most of the particle mass was in the small size ranges, the deposition fluxes were controlled by larger rapidly-depositing particles. The diurnal patterns of the total particulates deposition fluxes were determined by microscopic image analysis of the NRI samples. Mean daytime fluxes of the total particulates at urban sites were significantly higher than in non-urban area, but the night time mean fluxes were slightly lower than in non-urban area.

51. GENE EXPRESSION OF AMYLASE BY *IN SITU* HYBRIDIZATION IN CARNIVOROUS AND HERBIVOROUS PRICKLEBACK FISHES: ONTOGENETIC, DIETARY, AND PHYLOGENETIC EFFECTS

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We measured intensity of amylase gene expression in four species of carnivorous and herbivorous prickleback fishes (family Stichaeidae) and determined the effects of ontogeny, diet, and phylogeny

on this intensity. Of the four species, *Cebidichthys violaceus* and *Xiphister mucosus* shift to an herbivorous diet as they grow (>45 mm SL), whereas *X. atropurpureus* and *Anoplarchus purpurescens* remain carnivores throughout life. *A. purpurescens* belongs to a carnivorous clade, and the three other species belong to an adjacent, herbivorous clade. Gene expression of this carbohydrase in the four species was determined using *in situ* hybridization with an RNA probe and the intensity of expression quantified using image analysis. Intensity was compared in three feeding categories of the four species: (1) small, wild-caught carnivorous juveniles; (2) larger, wild-caught juveniles, of the two carnivorous species and the two that have shifted to herbivory; and (3) larger, juveniles produced by feeding a high-protein diet to small juveniles until they reached the size of the larger wild-caught juveniles. Comparisons of intensity in categories (1) vs. (2) allowed us to test for an ontogenetic effect, in (2) vs. (3) for a dietary effect, and within categories (1) and (2) for a phylogenetic effect. Our results showed no dietary effect in any species but significant ontogenetic and phylogenetic effects with the members of the herbivorous clade, *C. violaceus, X. mucosus* and *X. atropurpureus,* all increasing amylase gene expression with size and having higher expression than *A. purpurescens,* thus showing the importance of this carbohydrase in the herbivores.

52. A PETROGRAPHIC ANALYSIS OF A PALEOSOL IN THE LAS VIRGENES SANDSTONE, SANTA MONICA MOUNTAINS

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A paleosol in the Paleocene Las Virgenes Sandstone is exposed in Solstice Canyon, Santa Monica Mountains. It is approximately 8 meters thick and is divided into four zones. The lowermost zone is highly weathered sandstone. Zone 2 is a mottled interval, and Zone 3 is distinguished by pisolites. Zone 4 is characterized by silica replacement of pisolites and associated kaolinitic matrix. A petrographic analysis of the paleosol reveals that it contains mostly quartz, and a matrix of kaolinite with lesser amounts of highly altered feldspars and biotite. Monocrystalline quartz displaying dissolution features such as etching and embayments dominates all zones. Polycrystalline quartz is less common probably due to disaggregation. Most feldspar and biotite are altered to kaolinite and the kaolinite matrix likely resulted from this alteration. Zone 1 consist of 59% matrix 35% quartz, 5% feldspar, and 1% biotite. Zone 2 averages about 50% quartz, 43% matrix, 6% biotite and 1% feldspar. Zone 3 contains 60% matrix, 30% quartz and 10% pisolites ranging up to 6mm in diameter. Zones 4 consist of 43% quartz, 32% matrix and 25% pisolites, which range up to 3cm in diameter. Partially dissolved quartz grains occur in the cores of some pisolites present in Zone 3 and Zone 4 indicating that they formed after the alteration of the original detrital components. Partially dissolved quartz, kaolinitized grains, and pisolites are commonly associated with soils formed in tropical to subtropical environments. The paleosol studied in the Santa Monica Mountains likely formed in a similar environment.

53. GEOCHEMICAL ANALYSIS OF THE RICARDO VOLCANICS, SOUTHERN EL PASO MOUNTAINS, CALIFORNIA

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Whole-rock and trace element analyses of basalts from the Miocene Ricardo Formation were compared to geochemical data for other Cenozoic basalt fields of the Mojave. Ricardo volcanics have significantly lower alkali ($Na_2O + K_2O$) content and generally plot as tholeiites on a basalt tetrahedron. In contrast, basalts from other Mojave volcanic fields are distinctly alkaline in character. Ricardo spider diagrams are generally consistent with those for other fields, displaying the characteristic Mojave barium spike and incompatible element enrichment relative to the MORB standard. However, there is a slight depletion of some incompatible elements relative to other Mojave basalts. CIPW analysis of major oxides presents a paradox, Ricardo volcanics are consistently quartz normative, but in thin section olivine phenocrysts are present. Chemical similarities to the Big Pine field suggest the olivine might represent a xenocrystic mantle phase undigested by the Ricardo magmas. Any genetic model must explain the lower alkali content and differing incompatible element concentrations of the

Ricardo volcanics. Wang (2002) proposed that Cenozoic basalt composition varies from east to west across the Mojave and is a function of depth of melting. To the east, magmas tap deeper "enriched" mantle that would be expected to have higher alkali and incompatible trace element concentrations. Further to the west, shallower melting would result in slightly more siliceous, alkali-poor magmas from "depleted" mantle. Since the Ricardo field is the westernmost basaltic volcanic field within the Mojave, our geochemical data appears to support this hypothesis.

54. TESTING DIET SWITCHING AS THE MECHANISM FOR THE EVOLUTION OF STRICT HERBIVORY IN LIZARDS

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Herbivory is rare in reptiles and understanding why it evolves has been the subject of scientific speculation for more than 40 years. When captive herbivorous reptiles are raised on a diet that includes animal matter, they grow faster, reach a larger size, and produce more offspring. If eating insects is advantageous for captive herbivorous reptiles, then why don't herbivores eat insects in nature? We are testing the hypothesis that diet switching is energetically costly for herbivorous lizards. When insects become seasonally available, herbivorous lizards can make the switch from herbivory to carnivory without incurring an energetic cost because herbivores can digest animal matter as efficiently as carnivores. However, later in the year, when insects are no longer available, herbivores would have to switch back to eating plants. It is this switch that is predicted to be energetically costly because the endosymbiont community of the hindgut (bacteria and protozoa), which contributes substantially to the host's energy budget by fermenting cellulose into energy-rich volatile fatty acids, may be disturbed by changes in the gut milieu associated with a diet switch. We are assessing digestive efficiency in a model herbivorous lizard (*Dipsosaurus*) before and after diet switches and, using molecular techniques, predicted concomitant changes in the structure of the gut endosymbiont community. If this community is dramatically affected by changes in diet, digestive efficiency should decrease until the community recovers. This presumed disruption is predicted to be so energetically costly that it precludes herbivorous lizards from wholesale switches to eating insects in nature.

55. A POSSIBLE ORIGIN FOR A PALEOCENE QUARTZ-RICH SANDSTONE ASSOCIATED WITH A PALEOCENE PALEOSOL IN THE SAN JOAQUIN HILLS, CALIFORNIA

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Our research focuses on a petrographic comparison of detrital grains found in probable Paleocene paleosols exposed in the Santa Monica Mountains and the San Joaquin Hills, and in an anomalous quartz-rich sandstone also exposed in the San Joaquin Hills. Our preliminary findings suggest that detrital grains in the sandstone were derived from the paleosols. Petrographic results confirm similarities between quartz grains present in the paleosols and the quartz-rich sandstone, such as fracturing, etching and partial dissolution. Additionally, monocrystalline quartz grains are abundant in both the paleosol and the sandstone. These observations substantiate our interpretation that the quartz-rich sandstone is the result of a single cycle of erosion and deposition. Paleosols present in the depositional environment were eroded. Subsequently, the quartz grains originally present in the paleosol were concentrated to form the sandstones. More research is needed to further confirm our findings.

56. PUDDINGSTONE RESEVOIR PLANKTON POPULATION STUDIES, OCTOBER 2002-APRIL 2003

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Ecological assessment of urban reservoirs, such as Puddingstone Reservoir, in southern California's San Gabriel River Watershed, begins with establishment of baseline data for various biological and physical parameters. The purpose of this study has been to characterize the types of plankton and their population fluctuations over several months of the year.

Quantitative samples of plankton were collected in the upper 1 M of surface water from October 2002–April 2003, at approximately 2-week intervals from 2 sites. Numbers of phytoplankton and zooplankton were determined and patterns in population fluctuations were noted. Four main groups of phytoplankton were found: dinophytes, diatoms, chrysophytes, and cyanobacteria. The most common zooplankton consisted of two types of cladocerans and two types of copepods. Phytoplankton populations began with low abundance in October and November and steadily increased, peaking in December and January. A maximum near 800,000/L was seen on 1/26/03.

Zooplankton populations followed phytoplankton population patterns in a classic pattern, reaching their maximum near 500,000/L on 2/15/03. Population fluctuations among the different species of plankton are also discussed.

57. GENETIC DIFFERENTIATION WITHIN AND AMONG PYGMY NUTHATCH (*SITTA PYGMAEA*) POPULATIONS IN SOUTHERN CALIFORNIA

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We are sequencing mitochondrial DNA genetic markers to analyze the distribution of genetic variation among pygmy nuthatch (*Sitta pygmaea*) populations in southern California. Pygmy nuthatches are small songbirds resident in coniferous forest that occur in disjunct populations both in the mountains and along the central California coast of southern California. In order to determine the extent of gene flow among these disjunct populations, we will use mitochondrial sequence data to characterize the genetic differentiation among populations (i.e., mountain ranges) as well as any differentiation among subpopulations within mountain ranges,. Initially we are examining an approximately 3000-base pair region of the mitochondrial genome that includes the control region, ND6, the tRNAs for threonine, proline, and glutamine, and a portion of cytochrome *b*. Thus far, analysis of twelve individuals from five populations has yielded six haplotypes. This preliminary sequence data suggests strong differentiation between Laguna Mountain birds (*S. p. leuconucha*) and San Gabriel Mountain and more northerly birds (*S. p. melanotis*), while San Bernardino and San Jacinto Mountain birds show intermediate characteristics. Future work will include sequencing additional individuals from twelve sampling locations ($n \geq 6$) across eight populations within the study area, followed by population genetic and phylogeographic analysis of sequence data. This research will provide insight into the evolutionary ecology and natural history of the pygmy nuthatch, especially the degree to which gene flow occurs among populations of such a sedentary species.

58. *E. COLI* AND *ENTEROCOCCUS* IN SURFACE WATERS OF EAST SAN GABRIEL RIVER WATERSHED: LEVELS OF CONTAMINATION IN THREE FLOOD CONTROL CHANNELS AND SAN DIMAS CANYON CREEK

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Previous studies have indicated that high levels of *Enterococcus spp* bacteria enter Puddingstone Reservoir through influent water (Kocher 2001; Brady; in progress). The purpose of this paper has been to examine further the levels of bacterial contamination in the main watercourses leading into Puddingstone Res. and to identify possible sources of the contamination. Between 3/17/04 & 4/07/04, samples were taken at the mouths of the three flood control channels, which drain the sub-watershed into Puddingstone Res. and from 3 sites upstream of Puddingstone Channel, in San Dimas Canyon Creek, which flows from the Angeles National Forest. Samples were also taken directly from a drainpipe entering San Dimas Canyon Creek. Samples were tested in the University of La Verne labs. Replicate samples were analyzed at 3 Valleys Municipal Water District under the supervision of 3 Valleys lab personnel.

Preliminary results from 4 sample sets showed that, of the three, San Dimas Canyon Puddingstone Channel (SDCP Channel) was the major source of both *E. coli* and *Enterococcus spp* contamination entering Puddingstone Res. during dry periods, within the 5-week sampling timeframe. Following a rain event, however, *E. coli* and *Enterococcus spp* in the other two channels (Marshall Creek and Live Oak) increased to more than 2,410 (MPN) organisms/100mL and 2,000 (NPN) organisms/100mL, respectively—well above EPA standards.

Drainpipe water entering San Dimas Canyon Creek was found to be a major point source for both *E. coli* and *Enterococcus spp* contamination.

59. ASSESSING THE POTENTIAL FOR PALEOCLIMATE STUDIES IN CRYSTAL LAKE, SOUTHERN CALIFORNIA

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There are very few lake records of past climate change in Southern California. As part of a research initiative to understand better the region's baseline of natural climate variability, a series of lake research projects are being conducted throughout Southern California. One of the study lakes is Crystal Lake.

Crystal Lake is a natural water body located in the San Gabriel Mountains of Southern California. The lake's small drainage basin and direct recharge of water via precipitation run off, make the lake an ideal setting for recording a history of storm events. Based this reasoning, several cores were extracted from Crystal Lake in the summer of 2003 to assess the lake's potential for paleoclimate studies.

Total organic matter, total carbonate, mass magnetic susceptibility, and microscopic charcoal counts were measured on two lake sediment cores. In addition, a history of human activity, fire history, and precipitation data were obtained for the Crystal Lake area. Sediment age control was determined by correlating known anthropogenic and fire data with the measured sediment characteristics.

Based on the occurrence of regional fire activity and human development in the lake drainage basin in comparison to the lake's sedimentological properties, we have determined that Crystal Lake sediment does not contain a significant paleoclimate record. Rather, the lake sediments over the past 120 years record a combination of rapid sedimentation events related to human activities (i.e., construction of buildings) and fire occurrence (i.e, reduction in soil stability). Additional studies of longer sediment cores that pre-date human occupation (i.e., 1860 A.D.) are required to better assess the paleoclimate potential of Crystal Lake sediments.

60. SEASONAL BACTERIAL CONCENTRATIONS IN THE LONG BEACH/LOS ANGELES HARBOR COMPLEX

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Non-point source runoff can increase the amount of bacteria in surface and coastal waters. Freshwater outlets such as storm drains are found to be especially high contributors of bacterial contamination. Total and fecal coliform and enterococcal bacteria are used to indicate the likelihood of pathogenic organisms in surface waters. The presence of coliform bacteria indicates potential health risks to users of recreational waters, and enterococcus, specifically, has been shown to cause the stomach flu and other infections. These bacterial concentrations in rivers and coastal waters may be dependent on season, and have been linked to rainfall amounts, especially the first major rainfall of the season (the "first flush"). The amount of total coliforms, fecal coliforms (as estimated by *E. coli*), and enterococcus were tested seasonally and after the first flush at several sites in the LA/Long Beach harbor complex. The results yielded several overlying themes: 1) there is not an overall "seasonal" pattern—more wet vs. dry season pattern; 2) health limits were exceeded for most first flush and fall samples; 3) there were spikes in pathogen input to the harbor at Dominguez channel and the LA River; and 4) most concentrations abated by the time plumes reached the gates of the harbor breakwaters. Bacterial concentrations were also negatively correlated with salinity and positively correlated with turbidity. This pilot project will serve as a model for an additional 5-year monitoring project of the same area and will provide valuable data on the dynamics of bacterial concentrations in the harbor complex.

61. ISOLATION AND CHARACTERIZATION OF MICROSATELLITE LOCI OF YELLOWFIN GOBY, *ACANTHOGOBIUS FLAVIMANUS*

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To study the genetic consequences of the invasion of yellowfin goby into San Francisco Bay from East Asia, we have sought development of species-specific microsatellite loci to acquire allele frequency data for analysis. Microsatellite loci are highly informative genetic markers used in population genetic, linkage mapping, and parentage studies of many organisms, including fishes. More plainly, they are simple sequence repeats (SSR's) typically composed of two to four nucleotides such as $(GT)_n$ or $(GATA)_n$ where n is the number of repeats that is typically between 5 and 50. We developed microsatellite loci from total genomic DNA recovered from muscle tissue. The DNA was digested with *SAU*3A 1 to create restriction fragments of 200–400 base pairs used to produce a partial genomic library enriched in microsatellite loci. The critical enrichment step was the ligation of an oligonucleotide "linker" to the restriction fragments. The fragments were then hybridized to a 5′-biotinylated oligonucleotide probe of a repeating motif, $ATAGAATAT(CA)_{15}$. Hybridized DNA was then sequestered from the solution using magnetic beads. The sequestered fragments were amplified by PCR using the linkers as primers, and were then subcloned into TOPO TA cloning vectors that were used to transform *E. coli.* We screened clones for inserts by restriction enzyme digest, and those with inserts were screened for a microsatellite locus by direct DNA sequencing. We isolated microsatellite loci at rate of 1 out of 10 per clone positive for an insert. Of those clones 3 out of 10 proved to be variable.

62. EFFECTS OF LIGHT AND TEMPERATURE ON PHOTOSYNTHETIC RESPONSES OF THE INVASIVE INTERTIDAL SEAWEED *CAULACANTHUS USTULATUS* (RHODOPHYTA)

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Seaweed invasions appear to be increasing along the southern California coast. The 2002 appearance of the aquarium strain of *Caulerpa taxifolia* has been widely publicized; however, introductions of the Asian kelp *Undaria pinnatifida* and the intertidal red alga *Caulacanthus ustulatus* have received much less attention. Genetic analyses of *C. ustulatus* plants introduced to Brittany, France, indicated a western Pacific origin. Along the Pacific coast of North America, *C. ustulatus* is known to occur in Washington and British Columbia and also in Pacific Mexico. Recent studies performed in our lab revealed that *C. ustulatus* first appeared on southern California shores during the late 1990s. This species is now exhibiting invasive behavior and has become the dominant component of upper mid-shore algal turfs at several southern California sites near harbors and marinas where it grows on rock, articulated coralline algae, rockweeds, mussels, and barnacles. Culture studies of Brittany specimens indicate that *C. ustulatus* can tolerate temperatures of 6 °C to 26 °C, with best growth occurring at 17 °C. To date, however, few scientific studies have been performed on either native or invasive strains of *C. ustulatus.* and little is known about its biology or ecology. Here, we examine the photosynthetic responses of southern Californian specimens of *C. ustulatus* to light and temperature. We report Pmax, light saturation, and light-limited slopes (α) for *C. ustulatus* at 11, 14, 17, and 20 °C, a range of temperatures often encountered in southern and central California coastal waters. We compare our results with the published growth responses of *C. ustulatus* from France.

63. THE STATE OF SAN DIEGO BAY IN 1998: ECOLOGICAL CONDITIONS

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San Diego Bay is an important commercial and military port that harbors several important natural resources. The goals of the present study were to characterize physical, chemical and biological conditions of the Bay, identify long-term ecological trends within the Bay, and to address public concerns about the exposure to contaminants from eating local fishes. Most data were collected during the Southern California Bight (SCB) 1998 Regional Monitoring Project. Components of this survey included assessing sediment quality, macrobenthic communities, trawl-caught fish and invertebrate communities, and contaminant levels in fish tissues. Important results indicated: (1) several metals and PAHs were prevalent in sediments at concentrations exceeding biological impact threshold levels; (2) areas of high sediment contamination were associated with commercial shipyards, naval installations, and small vessel marinas where the percentage of fine sediments was often greatest; (3) hydrodynamic conditions appeared to be the primary factor that influenced the distribution of macrobenthic assemblages in the Bay; (4) contaminant levels in sediments were a secondary factor that appeared to be correlated with assemblage composition (5) metals were less prevalent in fish tissues than in sediments and rarely reached or exceeded human consumption limits; (6) PCBs and DDT were detected in almost all tissue samples; (7) DDT concentrations were below human consumption limits for muscle tissues, but both DDT and PCBs exceeded mammal predator protection limits for whole fish samples.

64. LOSS OF *accD* GENE FROM CHLOROPLAST GENOMES

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Insights from gene loss/transfer events in the chloroplast can be used to infer chloroplast evolution and plant phylogeny. The plant chloroplast gene *accD* appears to have been lost or transferred from the chloroplast genome in modern monocot plants. *AccD* encodes the β subunit of acetyl-CoA carboxylase, the enzyme that catalyzes the first step of fatty acid synthesis. Molecular and bioinformatic methods are being employed to find the point of loss of *accD* from the chloroplast genome. It is within the superorder Commeliniflorae (which contains the grass family) where the point of loss appears to have occurred. I am working on identifying the plant species where *accD* was first lost from the chloroplast genome. Chloroplast-residing *accD* has been found in some members of the family Commelinaceae while being absent in other members. We have identified the presence of *accD* in various members of Commelinaceae and other families in Commeliniflorae.

65. THE EFFECTS OF EXCESS ZINC ON DEVELOPING MURINE THYMOCYTES

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Zinc is one of several transition and heavy metals that is considered both a micronutrient and a toxicant, depending on its dose. However, excess extracellular zinc has recently been implicated in the modulation of various cellular processes such as the inhibition of cell death, as well as proliferation, secretion, and ion transport. Since cell death, or apoptosis, is a vital step during the selection of developing thymocytes, we investigated whether excess zinc would prevent apoptosis in developing thymocytes. We further investigated how zinc would affect the maturation and differentiation of these thymocytes. We cultured and incubated neonate mouse thymocytes in a range of zinc sulfate concentrations, then analyzed them with flow cytometry to compare frequencies of cell death, as well as ratios of CD4 and CD8 thymocytes. We found that the concentration of extracellular zinc correlated proportionally with resistance to dexamethasone-induced apoptosis in a dose-dependent manner, but only up to naturally toxic concentrations of zinc. We also found that the higher the concentration of zinc that thymocytes were cultured in, the further they progressed, developmentally, from $CD4^+/CD8^+$ (immature) thymocytes, to intermediate $CD4^-/CD8^{weak}$ (more mature) thymocytes. Since high zinc concentrations are common in the environment, and considering the effects that zinc.can have on developing immune cells, we suspect that excess zinc may be contributing to the rise in immune disorders such as asthma and respiratory allergies, as well as cases of lymphatic cancers.

66. SCRIPPS INSTITUTION OF OCEANOGRAPHY BENTHIC INVERTEBRATES COLLECTION

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The Scripps Institution of Oceanography Benthic Invertebrates Collection houses specimens collected from throughout the world's oceans by Scripps scientists. Collection materials are used to support graduate classes, scientific research, and educational programs at the Birch Aquarium. Published catalogs document Collection holdings of six invertebrate phyla. Material is made available for study to qualified researchers through visits to the Collection or by loan. The Collection is housed in a new building with compactor shelving provided by a grant from the National Science Foundation. A website ⟨http://collections.ucsd.edu/bi/index.cfm⟩ provides more extensive information regarding the Collection and downloads of catalogs available in digital format.

67. CLONING OF YEAST ENV GENES RESPONSIBLE FOR LYSOSOMAL PROTEIN TRAFFICKING AT A POST-GOLGI, PRE-VACUOLAR COMPARTMENT

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Recognition, sorting, and localization of lysosomal proteases to the degradative lysosome are vital for the operation of eukaryotic cells. In order to elucidate the steps involved in post-endosomal delivery of soluble hydrolases to the vacuole, we have isolated several *env* mutants of the yeast *Saccharomyces cerevisiae* that internally accumulate p2CPY but have intact secretion. The gene cloning strategy of two *env* genes (*ENV1* and *ENV2*) is conducted by the process of functional complementation. This strategy involves transforming the mutant cells with a yeast genomic DNA library and assaying for complementation by either a growth defect dependent screening for *ENV1* or colony immunoblotting screening for *ENV2*. A total of seven putative *ENV1* clones have been generated and sequencing confirms that all harbor the ORF containing the vacuolar protein sorting gene *VPS35*, suggesting that *VPS35* is the *ENV1* gene. However, complementation studies involving non-transformed *ENV1* mutants transformed with the genomic library constructs isolated from the putative clones yield mixed results indicating that the *ENV1* gene may not be *VPS35*. The exact relationship between the *VPS35* and *ENV1* genes is currently under investigation. Large scale screening of *ENV2* has yielded two complementing plasmids. The yeast DNA insert of the plasmid was partially sequenced and compared to the yeast gene bank. Putative ORFs were identified and will be checked in order to confirm the minimum complementing sequence by recombinant DNA methods. The characterization of additional selective agents for use in the growth defect-mediated functional complementation cloning of other *ENV* mutants is currently underway.

68. SEDIMENT CONDITIONS WITHIN SAN DIEGO BAY–RESULTS OF BIGHT'98 REGIONAL SURVEY

Dean Pasko, Daniel A. Ituarte, Eric C. Nestler, **Ami K. Groce**, Timothy D. Stebbins, R. Nicholas Haring. City of San Diego Ocean Monitoring Program, San Diego, CA 92101

This poster presents summaries and analyses of sediment grain size and chemistry data collected at 46 stations in San Diego Bay in conjunction with the regional Bight'98 survey. The contaminants examined include organic indicators, metals, polycylic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and pesticides. The results indicate that the highest levels of pollutants were widely distributed among commercial shipyards, naval installations, and small vessel marinas where the distribution of fine sediments was often the greatest. Stations with the greatest number of contaminants that exceeded recognized sediment screening criteria also tended to have the highest percentage of fine sediments. The potential for fine particles to sorb contaminants, and settle in areas of reduced water flow such as shipyards and marinas, may explain this distribution pattern. Metals and PAHs appear to be in decline within bay sediments when compared to historical levels. Pesticides and PCBs were also found in very low concentrations compared to previous studies; however, these lower detection levels (or lack of detection) may reflect differences in instrumentation or confirmation techniques used by the laboratories that conducted the studies. In addition, sediment conditions in San Diego Bay were compared to those of other bays and harbors sampled during Bight'98. Overall, the results of the 1998 survey of sediment quality conditions suggest that San Diego Bay contained lower concentrations of organic indicators and contaminants than many other Southern California Bight embayments.

69. STRUCTURE OF THE BENTHIC MACROFAUNA IN BAHÍA SANTA ROSALIITA, BAJA CALIFORNIA, MÉXICO

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In July 2001, 10 benthic stations were sampled in Bahía Santa Rosaliita, Baja California, México. Structure and composition of the benthic macrofauna were analyzed. A total of 3829 individuals, representing 234 species were identified. Polychaetous annelids constituted 53% (2,039) of the total macrofauna, followed by crustaceans with 33% (1,279), molluscs 12% (449), and echinoderms 2% (62). The nine most abundant species, contributing 46% of the total macrofauna were *Apoprionospio pygmaea* 13% (501), *Photis brevipes* 6% (232), *Spiophanes bombyx* 6% (231), *Polycirrus* sp A 5% (180), *Synchelidium americanum* 4% (156), *Oxyurostylis pacifica* 3% (114), *Caprella californica* 3% (111), *Tellina modesta* 3% (109), and *Ericthonius brasiliensis* 3% (102). Diversity and abundance of the benthic fauna decreased with increasing depth. Environmental stress defined by rarefaction analysis divided to the bay in two zones: (ZI) average stress, located at shallow stations; and low stress (ZII) located for rest of the bay. Analysis of classification and ordination based on a Bray-Curtis similarity and non-metric multidimensional scaling (N-MDS) separated the area of study in two groups of stations defined by depth, organic carbon and percentage of medium to fine sand.

70. MALE MORPHOLOGY AND CALLING SONG CHARACTERSTICS IN THE FIELD CRICKET, *GRYLLUS BIMACULATUS*

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Male field crickets produce calling songs to attract females. The characteristics of these songs may convey information regarding the species identity and phenotypic characteristics of the male. We examined how male morphological characteristics were correlated with calling song characteristics in *Gryllus bimaculatus*. We recorded the songs of individual males and measured the chirp rate, chirp duration, pulse duration, pulse carrier frequency and the degree of frequency modulation within a single pulse. We also measured morphological characteristics (e.g. pronotum width, tibia length,) of these males. Fluctuating asymmetry, a presumed measure of developmental stability or genetic quality, was estimated as the difference in tibia length between the right and left side. Song characteristics varied among individuals and there was a significant degree of frequency modulation. Pronotum width (an estimate of body size) was negatively with correlated carrier frequency and positively correlated with chirp rate. However, other morphological characteristics were not correlated with male calling song characteristics. These results demonstrate that calling song can convey information regarding male size but not fluctuating asymmetry.

71. MOLECULAR EVOLUTION OF THE CHALCONE SYNTHASE GENE FAMILY IN *DUBAUTIA LINAERIS* (HAWAIIAN SILVERSWORD)

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The silversword alliance of plants in the Hawaiian Islands, an exceptional model of adaptive radiation, evolved to become the twenty-eight silversword species seen today. Chalcone synthase (CHS) is the first committed enzyme in the anthocyanin pathway responsible for flower color and other phenotypes important in reproductive success. Because of the phenotypic advantage of color we are probably looking at key loci which can give insight into the radiation event.

I have isolated portions of the CHS genes from Dubautia linaeris. Optimization of reverse PCR is being implemented to extract the entire gene. Using other silversword and tarweed plants or DNA from other institutions I hope to sequence *CHS* in them as well. This can help predict the times of divergence of the species, their relationships, and shed light on evolution in this gene family and thus contribute knowledge to help in conservation efforts of this unique group of endangered/threatened plants.

72. PHYLOGEOGRAPHY OF *NORRISIA NORRISI* IN THE SOUTHERN CALIFORNIA BIGHT, WITH AN EMPHASIS ON GENETIC VARIATION BETWEEN DISTURBED AND UNDISTURBED HABITATS

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A phylogeographic study was conducted on the Norris' Top Snail, *Norrisia norrisi* (Archaeogastropoda: Trochidae) to assess if: (1) the species consisted of a single, large panmictic population within the Southern California Bight (SCB), (2) larval dispersal was affected by ocean current patterns, and (3) genetic diversity was negatively affected by habitat disturbance. Specimens of *N. norrisi* were collected from nine different locations within the SCB. In a 557 bp fragment of the Cytochrome

Oxidase subunit I mitochondrial DNA gene, 28 sites were polymorphic resulting in 24 haplotypes. A single haplotype was found in 53 of the 76 individuals and was the dominant type in all geographic locations. The sequence data were used to generate a haplotype network and calculate haplotype and nucleotide diversity statistics. The results showed a moderate to low haplotype diversity coupled with low nucleotide diversity, which suggested the occurrence of a recent population bottleneck. No clear connection was made between ocean current patterns and larval dispersal. Collection sites with high levels of arsenic and mercury were found to have significantly lower haplotype diversity than areas without high levels of these contaminants.

73. MOLECULAR ANALYSIS OF GENETIC VARIATION IN THE FEDERALLY ENDANGERED *ASTRAGALUS JAEGERIANUS* (FABACEAE, PAPILIONOIDEAE): A SPECIES WITH A RESTRICTED GEOGRAPHIC RANGE

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Analysis of genetic variation and population structure is being conducted on the federally endangered Lane Mountain milk vetch (*Astragalus jaegerianus*), a species with a geographic restricted range (approximately 35 km^2) within the Mojave Desert of southern California. Species with geographically restricted ranges often exhibit low levels of genetic variation, which puts them at risk of extinction or local extirpation. Conversely, species with limited ranges and geographically distinct populations can often be partitioned into genetically distinct populations. Five geographically distinct populations for *A. jaegerianus* have been delineated with 20 individuals sampled from each population. Five nuclear and chloroplast markers (nrDNA ITS 1–5.8S-ITS-2 cistron, and cpDNA trnL intron and trnL-F intergenic spacer) with known utility for phylogenetic and phylogeographic studies, have been sequenced for a subset of the plant samples from each population. Thus far, our data shows no single nucleotide substitutions or indels within the sequences (monomorphism), which suggests a low effective population size for the species. Additional work includes sequencing the DNA markers for the remaining plant samples for each population, and using AFLP technology on all plant samples to screen a larger portion of the genome for genetic variation. Effective conservation strategies for geographically restricted species require the assessment of genetic variation within and among populations. Such quantification is needed to reliably estimate numbers of individuals and populations needed for the long-term conservation of the species.

74. THE ROLE OF PLANT-SOIL FEEDBACKS IN COASTAL SAGE SCRUB RESTORATION ON SANTA CRUZ ISLAND, CA

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Plants have the ability to alter soil properties, such as nutrient pools via litter inputs, which may then feedback to alter plant performance and competitive outcomes between native and invasive species. The role of plant-soil feedbacks in influencing the reestablishment of the native shrub *Eriogonum arborescens* (Island Buckwheat) into alien annual grassland was investigated on Santa Cruz Island, CA. Through the Central Valley of Santa Cruz Island, mature stands of *E. arborescens* and *Artemesia californica* (sagebrush) dominate on shallow, rocky soils without grasses. In between areas dominated by shrubs or grasses, a mixed zone occurs, where native shrubs have begun to colonize the grassland. Transects were established through the transition zones to document relative percent cover of shrub and grass and plant size-class structure. Soil samples were obtained from underneath *E. arborescens* in the shrub only zone and mixed zone and underneath *Avena fatua* (Wild Oats) in the mixed zone and grass only zone. Soils were then tested for field moisture, water holding capacity, available nitrogen (NO_3^- and NH_4^+), organic matter content, N mineralization, and CO_2 respiration. If shrubs have the ability to alter soils as they establish, then soil characteristics under establishing shrubs (in the mixed zone) should differ from grass soils and more closely resemble soils in established shrub areas (shrub only zone). This, however, was not the case for any soil variable tested. Therefore, plant-soil feedbacks, in terms of nitrogen cycling, will not play a large role in native reestablishment efforts.

75. THE EFFECT OF SUBSTRATE SALINITY ON THE GROWTH OF *SALICORNIA VIRGINICA* L.

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Salicornia virginica, the dominant species in the Ballona Wetlands, is associated with relatively high substrate salinities in the field but a lack of response to elevated atmospheric CO_2 levels by plants grown at substrate salinities above 20 ‰ suggests that the physiological optimum may be lower. To determine the optimum substrate salinity for growth, rooted cuttings (Accession #: Co203–15, Tree of Life) were grown in quartz sand cultures and irrigated with 0, 5, 12.5, 20, 27.5, 35, or 40 ‰ NaCl. Additionally, as *S. virginica* is subjected to fluctuating salinities from tidal action, fresh water blending, and the high-winter, low-summer rainfall characteristic of the southern California climate, two fluctuating salinity treatments that averaged 20 ‰ (by weekly alternations of 0 ‰ and 40 ‰ or 12.5 ‰ and 27.5 ‰) were applied. Although biomass was greatest at 5 ‰ NaCl, *S. virginica* was tolerant of a broad range of salinities and significant decreases in biomass only occurred above 20 ‰ NaCl. Also fluctuating salinities did not alter growth by comparison to a constant 20 ‰. In the absence of NaCl, biomass, succulence, and branching were considerably reduced. Thus *S. virginica* shows salt-stimulated growth and tolerates broad and fluctuating substrate salinities.

76. PHYLOGEOGRAPHY AND PATTERNS OF GENETIC DIFFERENTIATION IN THE WESTERN FENCE LIZARD, *SCELOPORUS OCCIDENTALIS*, IN SOUTHERN CALIFORNIA

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Southern California is an area of high levels of faunal diversity and has exhibited a complex history of climatic and geomorphological change associated with this diversity. Certain species have broad distribution patterns in the western U.S. (including southern California) with only low to moderate levels of morphological differentiation that do not appear to reflect the complexity of faunal diversity or geological history in southern California. The western fence lizard (WFL) is one such species that is distributed from northern Baja California to Washington State and east to western Utah. Within southern California, one named subspecies is distributed across most of the region with separate subspecies found on the Channel Islands and along the coast from Ventura north.. We have carried out a study to investigate the general pattern of genetic differentiation in the WFL and to determine if the named subspecies are identifiable genetically. We collected lizards from over 70 populations in southern California and sequenced approximately 900bp of the NADH-4-Leucine region of the mitochondrial DNA. A phylogenetic analysis of these sequences indicates that there are four major lineages or clades present in the region with over 6% sequence difference between haplotypes from different clades and over 4% difference between hapolotypes within clades. Each of these clades is isolated geographically with relatively narrow boundaries between them. Except for the Channel Island subspecies, the pattern of genetic differentiation does not correspond to the named subspecies, but the degree of differentiation observed indicates that this species has been present in southern California for over 2 million years and the complexity is comparable to other southern California species groups.

77. MOLECULAR ECOLOGY OF A RIPARIAN AMPHIBIAN IN SOUTHERN CALIFORNIA: THE CALIFORNIA TREEFROG (*PSEUDACRIS CADAVERINA*)

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The California treefrog (*Pseudacris cadaverina*) is a stream-dwelling amphibian found in southern California and northern Baja California, Mexico. The habitat of *P. cadaverina* is confined to rocky streams. Because it requires perennial water, this species is geographically restricted throughout much of its range. In this study, DNA sequence data is being used to determine the nature and extent of phylogeographic structure among *P. cadaverina* populations in southern California. Of particular interest is how barriers to dispersal—such as watershed boundaries, deserts, and mountains—may have influenced this structure. Specimens have been collected from 38 localities spanning the species' range in southern California, including coastal and desert watersheds. Thus far, 1147 bp of mitochondrial

cytochrome b sequence data from 34 individuals have yielded 20 haplotypes across 13 populations. The mean sequence divergence within *P. cadaverina* is about 1.1%. *P. regilla* was used as an outgroup in phylogenetic analyses. Several geographically associated clades within *P. cadaverina* are supported by preliminary phylogenetic analyses and suggest broad divisions between coastal and desert populations. Further work will involve collecting cytochrome b sequence data from individuals representing additional populations across southern California as well as generating amplified fragment length polymorphism (AFLP) data. The conclusions of this study will shed light on the evolution and population genetics of *P. cadaverina* as well as provide information on the genetic connectivity of watersheds in southern California. Such information will be useful to conservation efforts in the region.

78. NUCLEAR GENE FLOW IN AREAS OF PRESUMED SECONDARY CONTACT IN THE WESTERN FENCE LIZARD, *SCELOPORUS OCCIDENTALIS* IN THE SAN GABRIEL MOUNTAINS OF SOUTHERN CALIFORNIA

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Previous research indicated the presence of 12 mitochondrially distinct clade groups that are distributed throughout the California range of the western fence lizard. Presumably, the geographic assortment of the clade groups of these lizards indicates isolation and secondary contract among clade groups. However, areas of introgression appear to be limited, and the conduction of respective mitochondrial DNA appears to the restricted to narrow bands (~12km) between populations that are fixed for particular clade memberships. To investigate the nature of the observed barriers to mitochondrial gene flow, 6 nuclear DNA microsatellite markers were scored in 22 populations of lizards. These populations included some that were fixed for a northern clade group, some that were fixed for a southern clade group, and some that were intermediate in clade group ratios. AMOVA indicated molecular structure among the populations, and pairwise Fst's revealed that the primary differences in allele frequencies did not reflect differences in mitochondrial clade group frequency. In fact, the allele frequency differences occurred between a group composed of 4 populations found on the northern slope of the San Gabriel Mountains. While the 4 populations showed great differences with nearly all other populations, no significant tests were found among them. Interestingly, these four populations represented all three aforementioned clade group characteristics. This pattern indicates that these four desert-adapted populations were subject to gene flow among them, with complete disregard to the mitochondrial barriers. These four are now assumed contain nuclear DNA that was adapted to survival in the desert environment.

79. ECOLOGICAL GENETICS OF THE TIDEPOOL COPEPOD *TIGRIOPUS CALIFORNICUS*

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Despite a seemingly high potential for dispersal, populations of the tidepool copepod *Tigriopus californicus* show extreme molecular differentiation over short geographic distances. For example, populations only 10 km apart can have up to 17% divergence in mitochondrial DNA. Two lines of evidence suggest that this high level of molecular differentiation is accompanied by relatively low levels of adaptive differentiation. First, fitness measurements under common garden conditions show significant effects of environment (temperature and salinity effects), but no significant population x environment interactions. Second, molecular population subdivision for 5 microsatellite markers was found to be considerable higher than quantitative trait subdivision for life history and morphometric characters ($F_{ST} = 0.80$, $Q_{ST} = 0.30$). The unusual pattern in *T. californicus* might be attributed to either restricted quantitative trait evolution or enhanced molecular evolution, both of which may be related to the harsh and variable physical conditions of the high intertidal habitat.

80. CONTRASTING DISPERSAL IN TWO CALIFORNIA ABALONE SPECIES USING A POPULATION GENETIC APPROACH

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Data from drifters released in the Santa Barbara Channel and Santa Maria Basin off southern California reveal local eddies and long-range currents that may retain abalone larvae or transport them great distances depending upon location along the coast and season. The red abalone *Haliotis rufescens* which spawns year-round in southern California and October through February in northern California, exhibits high genetic connectivity along nearly 1000 kilometers of coastline and may take advantage of multiple ocean current regimes that occur throughout the year, providing populations with both local recruitment (summer) and pulses of recruits from distant sources (winter). In contrast, the black abalone *H. cracherodii,* which spawns in late spring and summer when flow patterns display coastal eddying and jets of upwelling that may cause the retention or offshore movement of larvae, exhibits some restriction in gene flow along the Central Coast of California.

81. DIVERSITY, HISTORY, AND PHYLOGEOGRAPHY OF THE NORTHEASTERN PACIFIC COAST

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A significant component of marine diversity along the western coast of North America appears to have radiated in the Late Miocene and, in some cases, secondarily in the Pleistocene. Molecular and paleontological data document that the timing of these radiations is coincident with peaks of upwelling on the West Coast. Whereas perturbations in upwelling limited the diversity along other temperate western margins, several factors might have helped sustain diversity in the northeastern Pacific. These include continuity of upwelling, silica-rich subthermocline waters, and the trophic structure of the region's kelp forests. We suggest that much of the West-Coast diversity appears to be a relict of earlier upwelling regimes. Modern phylogeographic barriers along our coast also appear to be the product of geologic and climatic events of the Mio-Pliocene, Plio-Pleistocene, and Pleistocene-Holocene transitions. In the context of such events, we discuss phylogenetic patterns observed for variety of ecologically important taxa; *e.g.*, kelp, alcid birds, salmon, rockfish, abalone and cancrid crabs.

82. STOCK STRUCTURE ANALYSES OF SPOTTED DOLPHINS IN THE EASTERN TROPICAL PACIFIC OCEAN REVEAL A HIGH DEGREE OF FEMALE PHILOPATRY

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Mitochondrial DNA (mtDNA) control region sequences and microsatellite loci length polymorphisms were used to investigate genetic differentiation in spotted dolphins (*Stenella attenuata*) in the Eastern Tropical Pacific and to examine the intraspecific structure of the coastal subspecies (*S. a. graffmani).* One hundred and thirty five animals from several coastal areas and 90 offshore animals were sequenced for 455 bp of the mitochondrial control region, resulting in 112 mtDNA haplotypes. Phylogenetic analyses and the existence of shared haplotypes between the two subspecies suggest recent and/or current gene flow. Analyses using χ^2, F_{ST} values (based on haplotype frequencies) and Φ_{ST} values (based on frequencies and genetic distances between haplotypes) yielded statistically significant separation (bootstrap values $P < 0.05$) among five different coastal and the offshore strata. Samples were also genotyped for seven microsatellite loci. Again, F_{ST} indexes resulted in significant subdivision between offshore and coastal animals, but no population structure was detected within the coastal strata. This difference between the levels of genetic structure uncovered by mitochondrial and nuclear markers suggests the existence of male-biased dispersal, with females being highly philopatric. These results argue for the existence of at least five distinct coastal populations, which should be treated as separate units for management purposes and suggest the existence of male-biased dispersal among the coastal strata.

83. THE EFFECTS OF DISPERSAL AND HABITAT PREFERENCES ON SPECIATION IN CARIBBEAN MARINE OSTRACODES

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The cypridinid ostracode crustacean *Skogsbergia lerneri* is considered a widespread but monotypic marine species of the Caribbean. Previously, morphological variation had been noted among *S. lerneri* populations from different Caribbean localities. We sequenced 450 bp of the 16S rDNA mitochondrial gene from a total of 142 individuals from multiple habitats (reef, grassbed, mangrove, and sand) from the Florida Keys, Jamaica, Puerto Rico, US Virgin Islands, Mexico, Belize, and Panama. A total of 76 haplotypes were identified. Phylogenetic analysis revealed 6 major clades of haplotypes, each of which may contain multiple species. Although morphologically similar, the major clades within *S. lerneri* were as divergent in the 16S rDNA region (11–19% sequence divergence) as are genera of luminescent ostracodes from the same family. Haplotype diversity was high within habitats, but sequence divergence among haplotypes within habitats was low. Haplotypes were rarely shared among adjacent habitats or between localities, suggesting limited dispersal or reproductive isolation as a result of adult habitat preferences. Molecular evidence suggests that *S. lerneri,* as currently defined, consists of multiple species in the Caribbean.

84. APPLICATION OF BEAD ARRAY TECHNOLOGY TO COMMUNITY DYNAMICS OF MARINE PHYTOPLANKTON

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Studies of the dynamics of marine microplanktonic systems have been hampered by a lack of high throughput technologies for the simultaneous identification and quantification of the many taxa comprising such communities. To begin to address this problem, we developed a DNA-hybridization based method of analysis employing bead array technology. Species and/or genus specific probes for eight phytoplankton taxa were designed and applied to the microplankton community sampled from coastal waters in La Jolla, California over an exploratory time series 10 days in length. Bulk DNA extractions from 1 liter of seawater were used without PCR amplification. Taxa analyzed included four dinoflagellates, three diatoms, and one coccolithophorid. Results demonstrated that specifically targeted oligonucleotide probes can be used in this fashion with a high degree of binding specificity, dependent on hybridization temperature, and that standard curves relative to target cell concentration can be constructed. Use of two different probes for each taxon can provide added confidence that probes are taxon-specific. Further, single species assays and multiplexed assays were generally in good agreement, as were assays of replicate seawater samples. Once sets of probes are developed for particular groups of taxa, the bead array system appears to provide a technological platform with great promise for high throughput analyses of microplanktonic communities.

84a. GENETIC DIFFERENTIATION OF THE BIOLUMINESCENT MARINE FISH *PORICHTHYS NOTATATUS* (BATRACHOIDIDAE)

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Porichthys notatus is a species of toadfish that occurs along the Pacific Coast of North America from Baja California to Canada. *P. notatus* has hundreds of bioluminescent photophores on its ventral surface which collectively function as a counterillumination mechanism to avoid predation. *P. notatus* in the northern part of the range do not bioluminescence, apparently due to a lack of an available dietary source of the bioluminescence substrate luciferin. The objective of my research was to determine whether there is gene flow occurring between the luminescent and non-luminescent populations of *P. notatus.* Mitochondrial sequences from the 12S rRNA, cytochrome b, and COI genes were used to compare several individuals of *P. notatus* from multiple localities throughout its range. Little to no intraspecific variation was observed in the sequences obtained from 12SrRNA. No differences were observed in the fragment targeted with cyt b primers among the various localities. Intraspecific variability was observed in the COI gene, but the resulting tree demonstrates no phylogeographic structure. However, Fst and Nm values suggest differentiation among populations.

85. WHAT MTDNA TELLS US ABOUT THE INAVSION HISTORY OF YELLOWFIN GOBY IN CALIFORNIA-PART I.: THROUGH THE BOTTLE'S NECK?

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Yellowfin goby, an estuarine fish native to eastern Asia, was reported in the 1960s to have invaded San Francisco Bay (SFB) via commercial shipping, and then dramatically increased in population size.

Did a population genetic bottleneck accompany the invasion? Transient loss of haplotype diversity (h) can accompany population increases following a bottleneck. Although evidence of the loss can persist for some time afterward, h is difficult to interpret in that respect. A least-squares regression analysis of published sequence data from large populations of marine fishes presumably at mutation-drift equilibrium showed that singleton (single copy) mtDNA haplotypes occurred in constant proportion to the numbers of distinct haplotypes discovered. Finding significantly fewer singletons among California yellowfin than predicted from the regression could confirm any transitory loss of (mtDNA) alleles. We compared our singleton-count approach with h using mtDNA control region sequence data from yellowfin goby from SFB, two southern California estuaries (SC), and Honshu Island, Japan (HIJ). The singleton count for SFB was significantly lower than predicted from the regression (t = 4.13, $P<0.001$), but was not for SC and HIJ; however, h remained high in SFB and HIJ. The evident loss of rare haplotypes from the SFB population is concordant with a recent bottleneck, but how recent is a question. Comparison of the mismatch distributions of SFB and HIJ sequences show that both populations have undergone expansion, but the estimated age of the expansion pre-dates introduction to the California coast.

86. WHAT MTDNA TELLS US ABOUT THE INVASION HISTORY OF YELLOWFIN GOBY IN CALIFORNIA–PART II: HOW MANY INVASIONS?

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Yellowfin goby, *Acanthogobius flavimanus,* a fish native to the estuaries of Japan, Korea, and northeastern China, was first reported in San Francisco Bay (SFB) in the 1960s and is now established there. It appeared in southern California (SC) at LA Harbor in the early 1970s and has since spread to Upper Newport Bay and to south San Diego Bay, as well as to other estuaries between those two locations. Also in the 1970s it was first reported in the estuaries of New South Wales, Australia then later spread south to Port Phillip Bay in Victoria. Regarding the SC expansion we asked: Did yellowfin goby arrive to southern California from SFB or directly from Asia? Population genetic analysis using AMOVA of more than 200 mtDNA control region sequences of fish collected in two consecutive years from SFB and SC, and in a single year from Honshu Island, Japan (HIJ), found highly significant F_{st} and Phi_{st} values among all pairwise comparisons. The two commonest haplotypes in SC were altogether absent from among specimens of SFB. Genealogical analysis of the sequences using TCS found that nearly all of the haplotypes from SFB had derived from a single haplotype from HIJ. The same was true for six haplotypes from SC, but where four SC haplotypes had derived from one haplotype of SFB. Yellowfin goby of northern and southern California appear to have chiefly resulted from separate, possibly one-time invasions from Asia, but where SC might also have previously received some immigration from SFB.

87. MICROSATELLITE ALLELE FREQUENCY ANALYSIS OF *ACANTHOGOBIUS FLAVIMANUS:* EVIDENCE FOR POSSIBLE GENE FLOW BETWEEN SAN FRANCISCO BAY AND TOKYO BAY

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Yellowfin goby, *Acanthogobius flavimanus,* is an estuarine fish with a native distribution in eastern Asia. New populations of *A. flavimanus* now occur in San Francisco Bay (SFB) and harbors and estuaries of southern California. These new populations may consist of the offspring of a single founder event, where the population size has increased to detectable levels within the last 40 years, or they may be due to episodic transfer of individuals from the native range. Microsatellite allele frequency data from two polymorphic loci were used to evaluate relatedness between populations in SFB (winters of 2001–2003), Upper Newport Bay (spring 2003), Tokyo Bay (summer 2003), and the east coast of Japan (summer 2003). F_{st} values showed no significant difference between populations on the east coast of Japan, consecutive sampling years of the SFB population, the Tokyo Bay and SFB population sampled in years one and two, or between upper Newport Bay and SFB population sampled in year two. Microsatellite allele frequency data from three polymorphic loci were also used to test for a recent population-genetic bottleneck in SFB sampled in year one by comparing heterozygosities expected from Hardy-Weinberg equilibrium (H_e) with those expected for populations at mutation-drift equilibrium (H_{eq}), according to two models. The number of loci with apparent heterozygosity excess was not higher than expectation for a population at mutation–drift equilibrium; although, the minimum number of loci that should be so evaluated is three. Our results suggest contemporaneous gene flow between yellowfin goby of Tokyo Bay and San Francisco Bay.

88. INTRODUCTION TO THE SYMPOSIUM–ITS PURPOSE AND PLAN

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Catch & release regulations for both recreational and commercial fishing, mandated by state and federal agencies, are intended to protect both marine and freshwater fisheries. Do they? In this symposium, experts from around the United States and region focused their attention on the biological impacts of fishing-induced stress, as well as stress derived from other sources such as long-term captivity or pollution. What is presently known about the secondary impacts of stress responses was emphasized, particularly how induced stress factors (especially hormones) impact important aspects of physiology and behavior. The potential meaning of scientific findings to fish, fisheries, and fisheries management was also considered. The flow of the symposium was as follows. Stress —specifically stress responses— was introduced as a vertebrate phenomenon that is highly conserved and relevant in fish. The discussion then moved into fish and field, with a variety of research findings on fish presented, and ended with a more management-oriented perspective. At the conclusion of the symposium, an open forum afforded the opportunity for interested participants to provide input and to contribute to a discussion on the overall conclusions taken from the speakers, on future questions and issues in need of attention, and on possible management recommendations. For details on these discussions, we encourage you to go to www.csulb.edu/web/labs/sheephead.

89. THE FISH CASE-STUDY OF THE VERTEBRATE STRESS RESPONSE AND ITS RELEVANCE TO HUMAN-DERIVED IMPACTS IN MARINE FISHES

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Corticosteroid hormones (cortisol, corticosterone) play highly conserved roles among vertebrates as "stress hormones". These steroids (fish produce cortisol) mediate a variety of physiological changes that are generally adaptive for successful short-term responses to stressors, including mobilization of fuels to support greater energy utilization by muscle and other tissues, and reduction of energy-expensive processes including growth, reproduction, and immune function. Long-term stress responses (more than several days), on the other hand, become significantly maladaptive, as inhibition of the latter physiological processes cannot be prolonged without serious consequences to well-being and survival. Upon encountering a stressor from the environment, such as catching-&-releasing or exposure to an abnormal environment (e.g., contamination, captivity, human activities), fish typically exhibit a rapid (<1 min) but transient elevation in circulating levels of epinephrine (adrenalin) which is followed by a prolonged surge in plasma cortisol levels (initiated within several minutes). The cortisol surge is often profound (>50-fold in most fish) and will be sustained so long as the stressor remains; once the stressor is removed, cortisol returns toward baseline levels at a rate that differs among species. Importantly, the cortisol surge sets into motion other changes, among them alterations in endocrine regulators of tissue growth & repair. Studies done in our laboratory and in some others have demonstrated that an insulin-like growth factor-binding protein (IGFBP) is increased by cortisol and in several physiological conditions when cortisol is elevated and growth is inhibited. The highly consistent presence of this IGFBP in growth-inhibited fish has led to the proposal that it serves effectively as a biomarker for the growth impacts of stress. Interestingly, we have seen that the IGFBP remains elevated in plasma of stressor-exposed fish even after the surge in cortisol has subsided, suggesting that the physiological impacts of cortisol in fish outlast the initial stress-induced surge in cortisol. Thus, the secondary effects of stress (e.g., on growth) are likely to be of significant importance when considering the greater biological impacts of catch-&-release or other human-derived stressors. [Funded by CA Sea Grant College Prog. NOAA NA06RG042 2002–03, proj. # R/F-192, & NSF grant IBN0115975.]

90. REGULATION OF STRESS STEROIDS IN MAMMALS AND FISH: COMMON MECHANISMS AND DIFFERENCES

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A key hormone in the response to stress in vertebrates, from humans to fish, is the steroid cortisol, a glucocorticoid. This steroid acts by binding to a receptor, which undergoes a conformational change leading to binding of the cortisol-receptor complex to DNA and the regulation of transcription of genes involved in the glucocorticoid response. These responses include increased glucose metabolism—hence the name glucocorticoid- as well as suppression of the immune response, loss of calcium from bones and programmed cell death, apoptosis, and several other changes. For a long time, the glucocorticoid receptor (GR) was the main focus of research on the stress response. However, it is now clear that enzymes that regulate the concentration of cortisol that can reach the GR also are important in the stress response. One of these enzymes, 11β-hydroxysteroid dehydrogenase-type 2 (11β-HSD-2) catalyzes the oxidation of the C11-hydroxyl on cortisol to a ketone, yielding cortisone, an inactive steroid. This is a convenient on-off switch that conserves the steroid and allows it to be used. The recent cloning of 11β-HSD-2 from fish provides new insights into the regulation of cortisol levels in fish. Interestingly, 11β-HSD-2 also converts 11β-hydroxytestosterone to 11keto-testosterone, the active androgen in fish. Thus, 11β-HSD-2 is a key regulator of androgen and cortisol action in fish. Environmental chemicals that inhibit 11β-HSD-2 will have profound disruptive effects on endocrine physiology in fish.

91. CATCH-AND-RELEASE STRESS: IMPACTS ON THE ENDOCRINE PHYSIOLOGY OF THE CALIFORNIA SHEEPHEAD, *SEMICOSSYPHUS PULCHER*

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A catch-and-release policy was implemented several years ago by the state of California for undersized (≤ 30.5 cm TL) California sheephead, *Semicossyphus pulcher,* with the objective of reducing impacts of fishing pressures on this economically important species. It has not yet been established, however, whether the stress associated with catching and releasing has subsequent maladaptive effects. The impacts of catch-associated stressors on the endocrine physiology of *S. pulcher* were therefore examined, with an emphasis on how metabolism and growth may be altered. *S. pulcher* were caught offshore near Catalina Island using standard hook and line or commercial trapping. Controls (baseline) consisted of fish blood-sampled within 3 min of initial disturbance, which included catching and rapid retrieval to the surface as well as catching directly underwater while diving. Fish were subjected to the following stress-inducing protocols: 1) increasing angling fight times up to 20 min, 2) line-catching and confinement in tanks for 10 min to 30 d, 4) trap-catching with up to 5 h soak times, and 5) catching, releasing to the environment for varying periods, and then sampling of recaptured fish. In all experiments, plasma cortisol concentrations increased significantly and often dramatically in response to catch-associated experiences, in a manner commensurate with the time and intensity of the treatments. Following the elevations in cortisol were sustained increases in plasma glucose, while increases in lactate were more transitory. Plasma levels of a putative growth-inhibitory protein (IGFBP) were increased in stressed fish, along with alterations in IGF-I concentrations, yet no differences in plasma IGF bioactivity were detected in these experiments. Our data thus far indicate that captured *S. pulcher* experiences a profound stress response with associated metabolic impacts, while effects on growth regulatory factors are complex and not yet understood. [Support by CA Sea Grant College Program NOAA NA06RG042 2002–03, project # R/F-192 and NSF grant IBN-0115975]

92. PARASITES OF FISHES ASSOCIATED WITH WASTEWATER DISCHARGE AND THE POTENTIAL OF INFESTATION AND STRESS ON HOST FISHES

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During the Southern California Bight 2003 Regional Marine Monitoring Survey, select demersal fishes were collected and inspected for ectoparasites. While it is widely known that the southern

California marine environment has been subjected to numerous inputs of pollution, such as wastewater effluent, storm runoff, DDTs and PCBs, little is known about the effects of pollution on infestation of parasites on marine fishes. Exposure to pollution may result in stress, which may potentially decrease the immune response in fishes and increase their susceptibility to diseases and parasites. This study evaluates the conditions around wastewater outfalls in terms of infestation (e.g., prevalence and mean intensity) of ectoparasites on demersal fishes and examines if specific parasite and/or host species can be used as bioindicators of environmental stress in the Southern California Bight. A variety of marine organisms have been evaluated as potential biological indicators of various forms of pollution in the aquatic environment. However, due to the range of contaminants to which marine organisms are exposed, it is unclear which organisms and which anomalies are best used as indicators. The hornyhead turbot, *Pleuronichthys verticalis,* has been used as a model organism for indicating environmental stress. Levels of the stress hormone cortisol and infestation levels of ectoparasites were compared in groups of fish collected at various predetermined stations in the Southern California Bight. Preliminary results suggest an abnormal response in cortisol levels in groups of fish with high parasite prevalence.

93. ALTERED ENDOCRINE PHYSIOLOGY OF SOUTHERN CALIFORNIA FLATFISH COLLECTED NEAR WASTEWATER TREATMENT PLANT (WWTP) OUTFLOW–STRESS AND GROWTH

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Connections between environmental contamination and impairment of endocrine mechanisms regulating stress responses and growth in marine fish are not understood. Our studies are beginning to identify potential alterations in the endocrine physiology of local flatfish captured near the WWTP outflow of the Orange County Sanitation District (OCSD). Hornyhead turbot, *Pleuronichthys verticalis,* and English sole, *Parophrys vetulus,* are emphasized in these studies, as these species are typically present at depths and locations where the outflow pipes exist, thereby increasing their potential to be exposed to contaminants associated with effluents. Fish were caught by trawling at sites immediately proximal to the outflow and compared with fish caught at sites at varying distances therefrom. In comparison with fish from outside locations, individuals sampled near the outflow exhibited an impaired stress response, as they exhibited significantly blunted plasma cortisol surges in response to trawling and handling stressors. In addition, fish from the outflow locations have significantly reduced plasma concentrations of the growth-stimulatory hormone, insulin-like growth factor-I (IGF-I). The connections between cortisol, IGF-I, growth, and contaminants will be discussed. In conclusion, our data suggest that essential endocrine systems, namely those regulating the ability to respond to stress and regulating growth and anabolism, are significantly impaired in fish putatively exposed to WWTP effluents. [Supported by NSF grant IBN-0115975 & CA Sea Grant College Program NOAA NA06RG042 2002–03, project # R/F-192]

94. INTEGRATING PHYSIOLOGICAL AND BEHAVIORAL RESPONSES OF CALIFORNIA SHEEPHEAD EXPOSED TO FISHING-RELATED STRESSORS AND ITS IMPLICATIONS TOWARDS MANAGEMENT

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Many sport and commercial fisheries require release of undersized fish. However, often little is known about post-release survivorship or non-lethal effects on physiology and behavior. We compared the physiological and behavioral responses of California sheephead (*Semicossyphus pulcher*) caught on hook & line or traps. Small blood samples were taken from each fish exposed to different fishery methods to measure the level of cortisol (stress hormone) and metabolites (glucose and lactate). Behavioral effects were determined by monitoring the rate of movement and area use using acoustic telemetry. Fish caught via either method and rapidly blood sampled (< 3 min) showed basal levels of cortisol and metabolites. However, fish exposed to standard hook & line angling techniques showed time-dependent increases in these parameters, which were greater than those caught in traps. Fish that were caught on hook & line and then tagged with acoustic transmitters showed slower rates of movement and they covered less area in the first 6 hrs after release, as compared with than fish fed transmitters underwater. These results suggest that sport angling of sheephead induces stress-associated alterations in both physiological and behavioral parameters. However, fish released after stressful angling and trapping events may begin to recover from the physiological and behavioral alterations within 24 hrs. Results indicate that both fisheries induce similar, but differing magnitudes of physiological stress, yet longer-term post-release survivorship is high. [Support by CA Sea Grant College Program NOAA NA06RG042 2001–02, project # R/F-192].

95. GROWTH AND SURVIVAL IN JUVENILE WHITE SEABASS CAUGHT-AND- RELEASED ON OFFSET CIRCLE AND J-TYPE HOOKS

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The catch rate of juvenile white seabass *Atractoscion nobilis* has recently increased following an apparent increase in recruitment throughout Southern California, yet no information is available on the incidental hooking mortality of sub-legal (<711 mm) fish following catch-and-release. We captured juvenile white seabass (430–577 mm total length [TL]) from a net pen on 4/0 offset circle hooks (n = 113), 4/0 J-type hooks (n = 108), and with a net (control, n = 30) to investigate fish performance following release. The effects of hook type on the location of hook penetration, and how hook location affected growth and mortality were examined over the 130 day study. Circle hooks penetrated the lip region significantly more frequently (73%) than J-type hooks (41%). All white seabass mortalities sustained damage to the viscera, confirming that post-release mortality is directly correlated with the location of hook penetration. A 10% mortality rate was observed for fish caught-and-released on both circle and J-type hooks. All mortalities occurred within 5 d post-release. Mortality was reduced when deeply embedded hooks were left in place rather than being removed from the visceral tissue. Hook caught fish showed no reduced growth when compared with control fish, but deeply-hooked fish grew significantly less than fish hooked in the mouth. There was no significant difference in the angler success rates between hook types. We recommend that catch-and-release mortality be incorporated into the management plan for white seabass.

96. MOLECULAR INDICATORS OF CAPTURE RELATED STRESS IN SHARKS

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The post-release survivorship of hooked fishes is a key assumption underlying many fishing practices and the reduction of bycatch of non-targeted fishes. However, little is understood about how cellular stress-threshold-indicator levels correlate with the post-release survivability. Although, most fishes can recover from acute bouts of exhaustive exercise, intense and repeated struggling during capture may lead to significant tissue damage and critical disruptions to homeostasis resulting in higher rates of long-term (>30 days) post-release mortality. This study quantified the presence of specific molecular indicators of cellular stress (i.e., Hsp, heat shock proteins 70 and 90) in the blood of sharks with different levels of swimming activity (i.e., the active shortfin mako shark and the sluggish blue shark) in responses to capture with sportfishing gear and commercial longline gear. Preliminary results for sportcaught sharks show an increase in the levels of Hsps as a function of angling time (i.e., struggle stress) in the mako shark and relatively smaller response in the blue shark. No apparent pattern has emerged for the longline caught specimens. Taken together, this preliminary study provides an initial assessment of molecular stress response in sharks and will serve as the foundation for future studies on the long-term molecular responses to capture related stress in fishes.

97. THE PHYSIOLOGICAL EFFECTS OF CAPTURE STRESS IN TUNAS, BILLFISHES, AND SHARKS WITH INFERENCES ON POST-RELEASE RECOVERY

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Sharks, tunas, and billfishes are exploited by recreational and commercial fisheries worldwide, but quotas, minimum sizes, and bag limits result in the mandated release of large numbers of these fishes annually. Little is known of post-release mortality in large pelagic fishes and increased capture-induced mortality has important implications in quota management. To elucidate the physiological consequences of capture-induced stress in pelagic fishes, blood was sampled from 249 tuna, 217 sharks, and 6 marlin comprising 26 species captured on rod and reel, in gillnets, or on longlines. Changes in blood chemistry were correlated to parameters associated with the capture event and compared to baseline estimates derived from free-swimming fish. Blood gases, lactate and cortisol levels, and serum electrolyte, metabolite, and protein profiles exhibited significant quantifiable changes associated with the capture event. The magnitude and nature of these disturbances varied interspecifically with tunas exhibiting the greatest disruption. To investigate short and long term post-release behavior and survivorship, blood sampled fish were tagged with conventional and/or ultrasonic telemetry tags. To date, nine fish have been recaptured and seven bluefin tuna (*Thunnus thynnus*), three yellowfin tuna (*T. albacares*), three blue sharks (*Prionace glauca*), and two white marlin (*Tetrapturus albidus*) have been tracked. With the exception of one bluefin tuna, all the tracked fish survived the duration of the tracks, exhibiting behaviorally distinct recovery periods of ≤2hr. These observations support the hypothesis that pelagic fishes are capable of physiological recovery when handled properly and not subjected to extensive physical trauma.

98. CATCH AND RELEASE STRESS IMPACTS ON FISH: INTERGRATING RESEARCH FINDINGS INTO MANAGEMENT DECISIONS AND ANGLER CATCH AND RELEASE PRACTICES

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How can we incorporate research information on the impacts of catch and release stress on fish into effective management decisions and improvements in release methods? Researcher, managers and fishermen can work collaboratively to develop less stressful release techniques and improve fishery catch and release management rules. Anglers are great innovators whose expertise can be used in designing release devices and methods. Researchers can test how effective the methods are in reducing mortality and stress in fish. Managers can then incorporate the results into effective rules and regulations. Fishermen also should be included in the decision making process for developing catch and release regulations. They can provide important input into what regulations will be enforceable, effective and most likely to gain support among anglers. Buy in by the fishermen can increases compliance and reduce enforcement costs and is necessary for wide acceptance of voluntary catch and release practices. There are many important considerations to consider when designing catch and release methods including sub lethal effects (slow growth, predation vulnerability and reproduction disturbances), long term mortality (from infections, stress, predation), and the experience and fishing methods of fishers. Handling techniques may need to be specific to species and size of fish, environmental conditions, equipment and boats being used, and water depth. Yet the regulations and practices need to be enforceable (if mandatory) and easy to teach and use.

99. CHARACTERIZATION OF LIGHT HARVESTING-DEPENDENT, CHLOROPLAST LOCALIZED AtcDPPIV DIPEPTIDYL AMINOPEPTIDASE IN *ARABIDOPSIS THALIANA*

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We have used an EST microarray to find genes that show a light-harvesting dependent expression pattern. In our analysis of 7500 genes, one gene showed a clear light harvesting-dependent pattern with higher levels of mRNA observed at low light intensity, and lower mRNA levels at higher light intensity. PSI-BLAST analysis revealed that this gene has the highest identity to uncharacterized genes in soybean (81%) and rice (65%), but also had significant identity to genes found in three different environmental bacteria, *Xanthomonas campestris* (43%), *Chromobacterium violaceum* (43%) and *Caulobacter crescentus* (41%). These genes all contain the dipeptidyl aminopeptidase catalytic triad at the C-terminus. The human gene that is most similar to our gene is named DPPIV, so we named our gene *AtcDPPIV* to indicate it was a chloroplast-localized DPPIV homologue from *Arabidopsis thaliana*. Consistent with the predicted localization of the protease, AtcDPPIV:GFP fusions were shown to localize to the chloroplast using confocal microscopy. The mammalian DPPIV protease cleaves the two N-terminal amino acids from short peptide chains when the second amino acid is a proline. We are currently trying to determine the substrate specificity of AtcDPPIV. We have obtained two independent T-DNA insertions into the *AtcDPPIV* gene, one in exon 3 and one in exon 6. We have analyzed chlorophyll levels under growth at various light intensities in these *atcdppiv* mutants, but find no significant differences from WT. However, both mutant lines flowered earlier than WT.

100. HIGH-LIGHT INDUCIBILITY RETAINED IN A 216 BP FRAGMENT OF THE *ARABIDOPSIS ELIP1* PROMOTER

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Plants exposed to high-light intensities react to photooxidative stress by immediately triggering transcription of nuclear *ELIP* genes that encode early light-inducible proteins. ELIPs transiently accumulate in thylakoid membranes, and are quickly degraded upon return to low-light conditions.

Five *ELIP1* promoter fragments, ranging from 984 to 158 bp, were ligated next to the *GUS* reporter gene in pBI101, a plant transformation vector. *Agrobacterium*-mediated transformation of *Arabidopsis thaliana* wild type plants was done by the floral dip method. 14-day old transgenic seedlings were exposed to high-light-stress for 4.5 hours, to moderate light for 12 or 24 hours, while controls were left at low-light conditions.

The full-length, 984 bp, *ELIP1* promoter fragment conferred light responsiveness to the *GUS* reporter gene and a 130-fold induction in GUS activity was measured when plants were exposed to high-light-stress. 24-hour exposure to moderate light induced GUS activity only 20-fold, although levels of *ELIP1* mRNA significantly increased. A promoter construct that lacks the 5′-UTR was recently introduced into plants to determine if post-transcriptional regulation plays a role in *ELIP1* expression.

Deletion analyses showed high-light inducibility was conferred by promoter fragments of 579, 383, and 216 bp. The smallest fragment, 158 bp, exhibited significantly reduced photoinduction. These results suggest that the region between 216 and 158 is important for high-light-induced expression of *ELIP1*. PCR-based site-directed mutagenesis of three light responsive elements found in this region (GATA, CACGTG, CAAT), in the context of the full-length promoter, will reveal the *cis*-acting regulatory motif essential for high-light-dependent expression of *ELIP1* gene.

101. VESICULAR TRANSPORT TO THE YEAST LYSOSOMAL VACUOLE

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Selective recognition, sorting, and localization of proteins to the degradative lysosome via vesicular carriers represent an essential feature of all eukaryotic cells. Mislocalization of lysosomal proteases is associated with disease states including lysosomal storage diseases and cancer. Most lysosomal proteases are synthesized in the rough endoplasmic reticulum and transit through the early secretory pathway en route to the lysosome; they diverge from secreted proteins at a trans-Golgi compartment. One major post-Golgi pathway to the lysosome involves the endosome which is responsible for uncoupling of lysosomal proteases from their receptors. While several genes and gene-products have been identified at the pre-endosome and endosome stages of lysosomal delivery, post-endosomal events of lysosomal delivery of luminal hydrolases are relatively poorly defined. Our laboratory is involved in characterization of post-endosomal steps in lysosomal delivery using the yeast *Saccharomyces cerevisiae.* The yeast vacuole is functionally equivalent to the mammalian lysosome, and its carboxy peptidase Y (CPY)-pathway of vacuolar delivery parallels the mannose-6-phosphate pathway in mammalian cells. Yeast offers the advantage of well-developed genetics and molecular genetics. The objective of our studies is to define genes and gene products involved in the endosome to lysosome stage of targeting and delivery of luminal proteases that utilize the CPY-pathway. We have developed a novel mutant screen and have isolated mutants that exhibit internal p2CPY accumulation. The mutants display characteristics that suggest they may be blocked at late stages of carboxypeptidase delivery and processing from the *en*dosome to the *v*acuole (*env* mutants). We have characterized four *env* mutants genetically, microscopically and biochemically; and are in the process of cloning their putative *ENV* genes.

103. TARGETING OF NEUROLIGIN IN CULTURED HIPPOCAMPAL NEURONS

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Neurons elaborate two distinct types of cellular domains; axons, which transmit information to neighboring neurons, and dendrites, which receive information from neighboring neurons. The precise localization of proteins in axons and dendrites is critical for neuronal function. To achieve this local specificity, axonal and dendritic transmembrane proteins are first sorted into separate vesicle populations in the Golgi apparatus. Carrier vesicles are then transported to the plasma membrane via motor proteins and microtubules. Furthermore, synapse formation in neurons requires even finer protein localization within the membranous domains of the axon and dendrites. The aim of this study is to identify the targeting signal present in the cell adhesion molecule neuroligin. Neuroligin is a critical molecule in the formation of synapses however little is known about its subcellular localization in neurons and what signals govern neuroligin's targeting. In the current study we determined that neuroligin is polarized to dendritic cell surface of cultured hippocampal neurons and relies on a C-terminal motif for targeting. Since the formation of carrier vesicles relies on discrete stretches of amino acids, we are now determining which amino acids direct dendritic targeting. By understanding the basic cellular mechanisms of the neuron, we will better understand the cell biological basis for the development of the nervous system and the etiology of neurological diseases.

104. PRELIMINARY RESULTS FROM ANAVERDE VALLEY

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Monitoring of construction excavation on the former City Ranch has yielded numerous prehistoric archaeological materials. At least two horizons are represented—a late prehistoric near surface horizon and a probable Milling Stone horizon buried at about 40 cm. Chipped stone and debitage are relatively rare while ground stone is abundant. In the 500 acres graded thus far, no midden has been encountered. Thus, this portion of the valley appears to have been utilized as a processing area(s) with the village elsewhere. Results of the protein residue analysis and preliminary lithic analysis will be presented.

105. PRESERVING ORANGE COUNTY'S ARCHAEOLOGICAL LEGACY

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It has become clear that a crisis exists in American Archaeology—the non-renewable record of the human past is eroding before our eyes. Whether through unprecedented urban expansion or a lack of adequate care for excavated collections, the archaeological record is quickly deteriorating. As the number of intact archaeological sites decreases, archaeologists are becoming increasingly more reliant upon pre-existing collections for research. Given this trend, the accessibility and preservation of archaeological collections has become vital to the discipline. The County of Orange, California, sought and received a grant administered through CALTRANS, to develop and begin implementing a model curation program for its archaeological remains. This presentation will discuss the accomplishments of the Orange County Curation Project and will address the curation challenges that the region still faces.

106. THE USE OF FIRED-CLAY DAUB FROM CA-ORA-269 IN THE IDENTIFICATION OF PREHISTORIC DWELLING CONSTRUCTION METHODS, SAN JOAQUIN HILLS, ORANGE COUNTY, CALIFORNIA."

Ivan H. Strudwick. LSA Associates, Inc.

The principal type of prehistoric dwelling in southern California was wattle-and-daub. This type of dwelling was made by first constructing a circular, dome-shaped pole framework. Wattle, or bundles of woven sticks or reeds, was then placed upon this framework. The wattle was then packed with daub, which was clay or mud, to weatherproof the dwelling. When the structure burned, the daub was fired and became hardened, similar to fired pottery. Although daub is rarely identified on archaeological sites because it is similar in color and texture to local sediment, waterscreening and laboratory sorting

of excavated material substantially increases its recovery. Excavation of ORA-269 in the San Joaquin Hills near Upper Newport Bay resulted in the recovery of daub with impressions of vegetation and sometimes human fingerprints. Fingerprints indicate that it was applied by hand. Stick or pole impressions in daub sometimes exhibit a measurable curvature indicating that two general stick diameters were preferred. Thus, the presence of daub not only indicates that prehistoric structures were present, but its characteristics can be used to identify construction methods.

107. ROCK ART AND SOCIAL RITUALS: FEMALE PUBERTY CEREMONIES AND PETROGLYPH MOTIFS AMONG NATIVE CALIFORNIANS

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Ethnographic and historic sources document a metaphorical connection between female puberty rites and rattlesnake motifs among Native Americans of southern Alta California and northern Baja California, one of a broadly held set of beliefs shared among different indigenous groups. Interestingly, these sources also connect facial tattooing associated with female puberty rites to petroglyphs found in this area. Recent research suggests that rattlesnake motifs present at rock art sites may reflect the social practice of female puberty rites. Sites with these motifs have specific environmental features and archaeological signatures, and these patterns are illustrated in archaeological examples from Baja California.

108. THE ARCHAEOLOGY OF REGIONS: AN INITIAL REPORT OF THE WESTERN SANTA MONICA MOUNTAINS-OXNARD PLAIN PROJECT

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Archaeological research in the Santa Barbara Channel and Santa Monica Mountains region has been on-going for decades, but little systematic work has been completed at the regional level. The Western Santa Monica Mountains-Oxnard Plain (WSMOP) project has been initiated to reconstruct the ecological and cultural landscape of the region to determine how resources were used, where and when settlements were located, and what relationship exists, if any, between resource use and the eventual development of social complexity of the late prehistoric indigenous populations. This paper will address the preliminary work conducted to reconstruct the settlement locations in the region, and will consider the project's future plans and goals.

109. LARGE FRACTION FISH MATERIAL FROM SLO-2: FITCH (1972) REVISITED

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John Fitch (1972) published a paper on the otoliths, teeth, and fish scales recovered from an archaeological site in Diablo Canyon, San Luis Obispo County (SLO-2). The technique he used was exemplary because Fitch evaluated the matrix that was laboriously prepared using screens with meshes as small as 0.5 mm. He spent hundreds of hours microscopically sorting the material a spoonful at a time. The exhaustive efforts yielded the remains of over 40 fish species many of which were very small. The large fraction of the fish materials recovered during that excavation of SLO-2 was never evaluated. Over 30 years later we analyzed over 6,000 fish remains that have been in storage. These remains were recovered using 1/4″ screens and yielded fish material from at least 20 fish species, five of which Fitch did not identify. The success Fitch had with his recovery techniques provided another illustration of the need to utilize microscopic examination of matrix to maximize recovery of identifiable materials. These microscopic techniques are particularly important for the recovery of elements from tiny organisms that would not otherwise be noted.

110. THE TALEGA SITE AND ENCINITAS TRADITION PREHISTORY IN ORANGE COUNTY

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Human populations have occupied the Talega Site (CA-ORA-907) for at least the last nine and possibly the last eleven millennia. During this time, six meters of sediment have been deposited in short-term episodes separated by substantial periods of depositional stability during which pedogenic processes acted on the surface of the sediment body forming soils. These soils have produced abundant evidence of prehistoric human occupation divided into seven stratified cultural components. Cultural features include the remains of early Holocene dwelling as well as a large number of burnt rock features. Similarities in basic flaked stone technologies as well as architecture suggest cultural continuity throughout the occupation of the site spanning much of the Encinitas and Late Prehistoric occupation of the site.

111. THE CHIPPED STONE TOOLS OF CA-ORA-840, A MILLINGSTONE HORIZON SITE IN SOUTHERN ORANGE COUNTY

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Analysis of tool assemblages collected from archaeological sites can provide information about when the site was occupied, the activities of the residents, seasonality, and residential mobility, as well as how many different groups might have used the site. CA-ORA-840 is a Millingstone Horizon site situated ten miles inland on a bluff overlooking San Juan Creek. Excavators at CA-ORA-840 recovered almost 350 stone tools, over 400 edge modified flakes, and over 25,000 pieces of stone debitage. All of the stone tools were analyzed, as well as 25% of the edge modified flakes. Size, form, edge angles, edge wear, and material type were recorded. This paper discusses observed lithic tool types in the assemblage and suggests possible tool utilization, site function, and site occupation.

112. BOTANICAL TERMS AMONG THE UTO-AZTECAN SPEAKERS OF SOUTHERN CALIFORNIA

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The primary importance of plants to the lives and economy of Southern California Native Americans is well documented. Approximately 85% of their food was derived from plants; medicines, building material and baskets were derived from plants, as well as much of their clothing, tools, and ceremonial regalia. The cultural importance of plants is reflected in the linguistics of the region's tribes, there being over 220 named individual species and categories of plants. Linguistic, environmental, and cultural relationships exist between the several Takic speaking social groups, the Gabrielino and Serrano of the Northern (Serran) Takic Branch, and the Cahuilla, Cupeño, Luiseño and Acjachemen of the Southern (Cupan) Takic Branch. The native terms among these peoples for 175 plants were reviewed. The great majority of the terms are very similar from one language to the next, and even from one language branch to the other, more so on average than with the rest of their vocabulary. Most differences, or gaps, are likely the result of different environmental conditions rather than strictly cultural.

113. FISHING AND MARINE MAMMAL HUNTING PATTERNS FROM A 2500- YEAR OLD CAMPSITE ON SAN NICOLAS ISLAND

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Preliminary archaeofaunal results are presented from a 2500-year old campsite on San Nicolas Island, the most isolated of the southern Channel Islands. Data indicate that large quantities of fish and a smaller number of sea mammals were transported to this campsite, which is in the highest area of the island and several kilometers from the coast. At least 10,000 bone fragments are represented in the vertebrate archaeofaunal assemblage. California sheephead (*Semicossyphus pulcher*), indeterminate surfperch (Family Embiotocidae), and cabezon (*Scorpaenichthys marmoratus*) are among the identified fish species. As indicated by the presence of large numbers of cranial and post-cranial remains in the assemblage, most of the fish were transported to this site as complete individuals, where they were butchered, cooked, consumed, and discarded. Marine mammals include sea otter (*Enhydra lutris*) and pinnipeds. Small portions of whalebone are also represented. Cutmarks from butchering are evident on several otter elements. Hunting and fishing patterns are discussed with regard to prehistoric local and regional overexploitation and resource depression in the late Holocene. Since archaeofaunal studies can provide long-term trends in animal population dynamics, the data have implications for modern conservation biology in the Channel Islands.

114. THE ROLE OF MACROPHYTES IN THE DIETS OF THE SUSPENSION- FEEDING MUSSEL *MYTILUS CALIFORNIANUS* ON SOUTHERN CALIFORNIA SHORES: A CARBON ($\delta^{13}C$) AND NITROGEN ($\delta^{15}N$) STABLE ISOTOPE ANALYSIS

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Benthic intertidal consumers can obtain food derived directly or indirectly from both phytoplankton and macrophyte (algae and seagrass) sources. Carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotopes have been used successfully to show that macrophyte production, particularly through detrital pathways, is an important contributor to benthic consumer diets in colder seas characterized by large algal beds. The purpose of this study was to examine macrophyte contributions to food webs on southern California shores by focusing on *Mytilus californianus,* a suspension-feeding mussel found in abundance throughout the region. Dietary inputs to mussels were determined by comparing $\delta^{13}C$ and $\delta^{15}N$ values for multiple macrophyte and phytoplankton sources with the stable isotope signatures for mussels collected from urban coastal and offshore island habitats characterized by variable macrophyte standing stocks. $\delta^{13}C$ stable isotope values averaged −14.8 ‰ for macrophytes and −21.0 ‰ for phytoplankton-containing ocean POM. Using these values in a two-source mixing model, we calculate that macrophytes contribute approximately 50 % of the carbon to mussel diets at all of our mainland sites, even those lacking large algal or seagrass beds. Mussel $\delta^{15}N$ values were similar among sites with a mean of 11.0 ‰ and were enriched by 1.5 ‰ over nitrogen values in macrophyte and POM sources. Mussels from Santa Catalina Island, an offshore, oligotrophic site, had distinct and more depleted $\delta^{13}C$ values (-18.7 ‰) compared with mussels from the mainland, indicating greater dietary contributions of planktonic POM.

115. AGE AND GROWTH OF THE ROUND STINGRAY, *UROBATIS HALLERI,* AT SEAL BEACH, CALIFORNIA

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The round stingray, *Urobatis halleri,* is a common nearshore elasmobranch, occurring in high numbers at Seal Beach, California. The round stingray is investigated to estimate the age and growth parameters of the population, which can be applied to demography and management of the population. In elasmobranchs, growth rings that form in the vertebrae are used to estimate age. Round stingrays were collected during monthly beach seines in 2003. A subsample of ten stingrays per month were sacrificed and a section of the vertebral centra was used to estimate age (n = 84). The von Bertalanffy growth model was applied disc width at estimated age producing a maximum disc width of 241.3 mm for both sexes combined. The oldest animal was estimated to be 14 years of age with a disc width of 239 mm. The predicted maximum disc width is smaller than the reported 300 mm maximum disc width for round stingrays, but is larger than that of related species like the stingaree, *Urolophus lobatus.* The growth coefficient (k) of 0.23 estimated for the round stingray falls within the accepted range of 0.1 to 0.3 for elasmobranchs but is two to three times smaller than that of *Urolophus lobatus.* Other related species like the bat ray, *Myliobatis californica,* have larger maximum disc widths and smaller growth rates. Preliminary analysis suggests that the round stingray may show longevity of ten to fifteen years and may show intermediate growth rates compared to other elasmobranch species.

116. ASPECTS OF THE LIFE HISTORY OF THE BLACK CROAKER (*CHEILOTREMA SATURNUM*) FROM WITHIN THE SOUTHERN CALIFORNIA BIGHT

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The black croaker, *Cheilotrema saturnum* (Girard), is a common member of the nearshore fish assemblage off Southern California. Overnight gill nets were set bimonthly from April to October from 1995–2003 to sample the nearshore ichthyofauna. Black croaker were collected and processed to determine their physical characteristics, sex ratios, growth, reproductive periodicity and distribution (both size and spatial) throughout the range of sampling. Specimens ranged from 126 to 362mm standard length and 40 to 750g total weight. The mainland was found to support a significantly greater population than the offshore Channel Islands. Conversely, specimens captured at the Channel Island were significantly than those from the mainland. The sex ratios over age and length indicated a gonochoric pattern, with the primary spawning period being late spring early summer based on gonosomatic indices. Catch per unit effort (CPUE) data suggests the Palos Verdes Peninsula supported the largest population sampled within the Southern California Bight.

117. MICROHABITAT COLOR PREFERENCES OF FOUR *TEGULA* SPECIES IN DANA POINT, CALIFORNIA

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Although the influences of both physical and biological factors on the distributions of rocky intertidal organisms have been well studied, little information exists on the influence of microhabitat colors on those distributions. In the present preliminary study, microhabitat color preferences of four *Tegula* snail species (*Tegula funebralis, T. gallina, T. eiseni,* and *T. aureotincta*) from Dana Point, California were determined by exposing snails in the laboratory to colors and observing the preferred fields. Both *Tegula eiseni* and *T. aureotincta* showed no preference for any of the colors tested, whereas, *T. funebralis* and *T. gallina* most often selected fields with darker colors. Attempts were also made to determine if the *Tegula* snails used visual cues to identify food, predators or other *Tegula* snails. Field studies at Dana Point were also conducted to determine if similar color preferences as those observed in the laboratory also existed under natural conditions.

118. GENE FLOW AMONG SPOTTED SAND BASS, *PARALABRAX MACULATOFASCIATUS*, POPULATIONS WITHIN THE SOUTHERN CALIFORNIA BIGHT

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It is the goal of this study to examine the degree of genetic structure among populations of the spotted sand bass, *Paralabrax maculatofacsiatus* within the southern California bight. Within the southern California bight, *P. maculatofacsiatus* are found to inhabit shallow warm-water habitat such as bays and harbors, which provides a warm water refuge for this species. Due to this unique habitat requirement, movements of individual adult fish are restricted, thus, gene flow among populations is accomplished through long-range dispersal of eggs and larvae via coastal currents. Hence, *P. maculatofacsiatus* serves as an ideal model to test the role of gene flow among geographically distant populations. The degree of genetic variation will be investigated through the amplification and direct sequencing of the mitochondrial control region. Comparison of DNA sequences will be used to test the null hypotheses of no difference in genetic variation both, among population and among age classes within populations. The information gained from this investigation will enhance both our understanding of the level of genetic diversity among *P. maculatofacsiatus* populations as well as the level of connectivity among populations of marine of organisms with a pelagic dispersal phase.

119. THE *CYP1B1* L432V POLYMORPHISM AND RISK OF COLORECTAL CANCER

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The *CYP1B1* gene is located on chromosome 2p21-p22 (Tang et al., 1996) and is a member of the cytochrome P450 family. The cytochrome P450 family is involved in the metabolism of many substances including procarcinogens. *CYP1B1* is involved in the metabolism of procarcinogens such as polycyclic aromatic hydrocarbons and heterocyclic amines into genotoxic metabolites (Shimada et al. 2001, Oda et al. 2001). These heterocyclic amines are associated with colorectal cancer. The Leu to Val polymorphism at codon 432 in exon 3 was found to be associated with susceptibility to head and neck squamous cell cancer in smokers (Ko et al., 2001). The Leu / Val variant has also been found to be associated with colorectal cancer in one study of German individuals (Fritsche et al., 1999). The *CYP1B1* L432V polymorphism should be associated with an increased risk of colorectal cancer because it is involved in the metabolism of heterocyclic amines.

In this experiment, four ethnic groups were studied to see whether they had a difference in gene frequency of the *CYP1B1* L432V polymorphism. Four ethnic groups were included in this study, the

Asians, the Blacks, the Latino Whites, and the Non-Latino Whites. Sample DNA were from subjects who underwent a sigmoidoscopy in either of the two Southern California Kaiser Permanente Centers (Bellflower and Sunset, CA) during the period from January 1, 1991 to August 25, 1993. The samples DNA were subjected to PCR amplification and *Pst*I digestion. The PCR products were ran through gel electrophoresis. The results suggest the Blacks had an increased frequency of the polymorphism while Asian Pacific group had an increased frequency of the homozygous C/C genotype. Further analysis is necessary.

120. THE EFFECTS OF DYNEIN AND KINESIN ON THE INTRACELLULAR MOVEMENTS IN THE PARIETAL CELLS

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The parietal cells are found within the stomach lumen that secretes hydrochloric acid. H, K-ATPase is the protein pump, which is responsible for acid secretion. When there is a stimulus, H-K, ATPase is moved from the cytoplasm to the apical membrane. When H, K-ATPase is at the apical membrane, acid secretion starts. I believe that the movement of H, K-ATPase involves two microtubule based motor proteins, Dynein and Kinesin. This is because motor proteins have been known to be involved in intracellular movements in other body parts' epithelial cells. These motor proteins transport organelles inside the cell along a filamentous track. I decided to do a project to see if the motor proteins are involved in the movement of H, K- ATPase in parietal cells. I had two problems: Are microtubule based motor proteins, dynein and kinesin, involved in the intracellular movement of H, K-ATPase in the parietal cells? If so, what role do they play? I propose to do this through Western Blots and Immunofluorescence. Before I work with western blots, I had used Coomassie blue stain to see if there is any H, K-ATPase present in the proteins. After my experiments, it was found that H, K-ATPase was found present in all of the protein samples. It was also found that dynein was found in the gastric tubulovesicles. With my results, I can conclude that H, K-ATPase is a major component found in the parietal cells. The protein pump moves back and forth of the basolateral surface and apical membrane through dynein and kinesin.

121. ANALYSIS OF FERRITIN EXPRESSION IN VARIOUS CELL LINES WITH FLOW CYTOMETRY

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Cancer is known to be the second leading cause of death. The purpose of this study was to analyze the expression of the iron-storage protein heavy-chain ferritin in various cancer cell lines. A correlation was predicted to be the higher amount of ferritin, the higher amount the regulatory T cells will be activated. Previous studies showed that melanoma cell lines that expressed ferritin had higher percentages of T-regulatory cells. The cell lines analyzed include: Raji, MT-1, YT-2C2, TPH-1–0, DEV, L540, Colo 667, Holm-3, Su-DHL-4, Su-DHL-6, Su-DHL-10, and Su-DHL-16. Each cell line had 3 sample tubes: control, cells with the secondary antibody only, and stained. The TPH-1–0 cell line showed the highest percentage of ferritin expression (98.13%) and the Su-DHL-16 came in second highest with a ferritin expression percentage of 80.28%. The DEV cell line had the lowest expression of ferritin (2.74%) with its secondary antibody control expressing a ferritin percentage of 3.85%. This means that the DEV cell line does not contain ferritin at all. Future studies will involve injecting ferritin-positive cell lines into separate mice. The cells will be collected and stained to determine whether there is a correlation between the amount of ferritin and the regulatory T cells or not.

122. IDENTIFYING NEURAL REGIONS RESPONSIBLE FOR LIFESPAN IN DROSOPHILA

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Towards the identification of the neural regions that regulate the longevity of Drosophila I am selectively targeting a dominant negative of the Shibire gene, which controls vesicular trafficking at synapses to brain regions and subsequently assaying the effect on longevity. The Shibire gene is temperature sensitive, inactive at 29° C. I have obtained a vast panel of GAL4 'driver' lines that are expressed in different brain regions. I am using these lines to screen for neural regions that when silenced, via Shibire, confer enhanced longevity. 102 potential candidates were tested and I have identified one candidate GAL4 line which displays longevity, by surviving for 43 days, as compared to the wild type that survives for 30 days; the strain outlives the wild type by 13 additional days, approximately 43%. Using fluorescent microscopy, I identified the neuronal expression, and found the GAL-4 to be expressed in the mushroom body which is homologous to the hippocampus in animals. From this research it can be concluded that the mushroom body plays a vital role in determining lifespan, and can be used to study the role of brain structures and their functions in different neurodegenerative diseases.

123. THE EFFECTS OF PROGESTIN ON THE HORMONE RECEPTOR CONTENT OF HUMAN ENDOMETRIAL EXPLANTS

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Anti-progestin, mifepristone has been recently demonstrated to diminish breakthrough bleeding in users of progestin contraceptives. The purpose of this study was to investigate the use of cultured endometrial explants to study the effects of mifepristone and medroxyprogesterone acetate (MPA, progestin) on endometrial sex steroid receptors. To address this question, I used endometrium obtained by biopsy during the secretory phase, and cultured for 72 hours in the absence and presence of MPA, mifepristone and MPA plus mifepristone, respectively. Explants were then frozen for total RNA isolation or fixed in 10% formalin for morphological and immunohistochemical analysis. I found that the tissue showed little or no necrosis up to 72 hours of culture on H & E staining. Immunostaining with anti-Ki67 antibody, a proliferation marker further demonstrated the viability of the explants. The expression changes of hormone receptor following the treatment were confirmed by both RT-PCR and immunohistochemical analysis. From this study I learned that the tissue viability of endometrial explants can be maintained in culture up to 72 hours. The explants culture can be used to directly evaluate the induction or repression of gene products in the human endometrium by progestins and anti-progestins. The culture of endometrial explants offers the advantage of maintaining the tissue in a similar environment as *in situ.* Several studies based on the culture of explants or isolated endometrial cells have greatly enriched our knowledge on the effect of ovarian steroids on endometrium.

124. INHIBITING THE GROWTH OF AN EWING SARCOMA TUMOR CELL LINE USING SIRNAS DELIVERED AS COMPLEXES TO CDPS THAT TARGET THE EWS/FLI-1 ONGOGENIC FUSION GENE

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Ewing sarcoma is a cancer caused by a chromosomal translocation t(11;22) that often results in the generation of the EWS-Fli-1 fusion gene. Intracellular levels of this fusion protein can be reduced by targeting the messenger RNA transcript for degradation through a process called RNA interference (RNAi). RNAi is achieved by delivering small interfering RNAs (siRNAs) to the cytoplasm of cells causing the inhibition of growth. Commercially available lipids as a delivery vehicle are too highly toxic, rendering it unsuitable for the target application for siRNA as a therapeutic. Therefore, the laboratory of Mark. E. Davis synthesized cyclodextrin-containing polycations (CDPs), which have been shown to be effective delivery agents for DNA and small molecules in cultured cells and animals. The primary objective of this study is to inhibit the growth of an Ewing sarcoma tumor cell line by delivering siRNAs as complexes to CDPs that target the EWS/FLI-1 fusion gene. First, determined the ratios of CDP to siRNA necessary to form complexes using dynamic light scattering and gel electrophoresis. Next, I examined the uptake of complexes made with fluorescently labeled siRNAs in cultured Ewing sarcoma cells at a variety of siRNA doses using a process of flow cytometry. Results have proven that the ability of siRNA can uptake cellular growth. I hope to continue further study in determining the cellular growth kinetics, variations in CDP-to-siRNA ratios, and sequence specificity of the effect of siRNA. For, enhancement of greater knowledge will prove more successful discovering a cure for the Ewing sarcoma cancer.

125. PROGESTERONE RECEPTOR EXPRESSION AND LOCALIZATION IN ADULT MONKEY TESTES

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Over the decades many female contraceptives have been created and modified. There have been no big advances on the male contraceptives—condoms and vas occlusion. Hormone male contraceptives, similar to female birth control pills, are still in the trial stage. Demonstrations have proved that the addition of testosterone combined with progestin (synthetic form of progesterone) suppresses spermatogenesis and is more effective than the other preventatives. Besides further suppressing the gonadotropins (hormones that stimulate the testes), progestin may have a direct effect on the testes, with the help of the progesterone receptor (PR). To determine whether the progesterone receptors were expressed, and where they were localized in adult cynomolgus monkey testes, testicular samples from 8 adult monkeys (7–10 years old) were used in this study. Testicular biopsies were performed on the monkeys in aseptic conditions under anesthesia. One portion of each of the testicular samples from each animal was frozen into liquid nitrogen for Western blot, and another portion was fixed into Bouin's solution, paraffin embedded, and sectioned for immunmohistochemistry. The results showed in the Western blot analysis the presence of three bands migrating at approximately 114 kDa, 94 kDa, and 60 kDa, which parallel the molecular weight corresponding to PR-B, PR-A, and PR-C. The immunohistochemical analysis showed the presence of positive PR immunoreactivity intracellularly in Leydig cells, Sertoli cells, pachytene spermatocytes, and elongated spermatids in the adult monkey testis. We conclude that PRs are expressed in the monkey testes. The functional roles of the PRs have yet to be examined.

126. THE DISTRIBUTION AND BINDING PARTNERS OF KINESIN II IN RABBIT LACRIMAL ACINI

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Kinesin II is a motor protein that drives the plus-end transport of membrane organelles along microtubules. This study explored the role of kinesin II in lacrimal acinar membrane trafficking. Cultured rabbit lacrimal acinar cells were treated with 100 μM carbachol (CCH) for 15 min. Confocal microscopy of resting acini revealed kinesin II immunofluorescence in a punctate pattern beneath the apical membrane and throughout the cytoplasm with colocalization with rab6, rab11 and p150^{Glued}. CCH stimulation increased the intensity of kinesin II beneath the apical membrane and the extent of its colocalization with rab11 and p150^{Glued}. Analysis of kinesin II distribution on membranes isolated over sorbitol density gradients revealed enrichment in fractions 5–12. CCH induced an increase of kinesin II in fractions 5–7. CCH enhanced the co-immunoprecipitated p150^{Glued} from cell lysates by antibody to kinesin II. The increase in kinesin II-p150^{Glued} association in CCH-stimulated acini was confirmed in co-immunoprecipitation of kinesin II with antibody to p150^{Glued}. The following can be concluded from the results: in CCH-stimulated acini, p150^{Glued} is present on secretory vesicles driven into the apical region by cytoplasmic dynein. Coupled retrieval of exocytosed membrane by kinesin II from subapical endosomes to the Golgi may be mediated by its regulated binding to p150^{Glued} once cytoplasmic dynein is released.

127. SUSCEPTIBILITY OF OXIDATIVELY CROSSLINKED AMYLOID BETA-PROTEIN TO INSULIN-DEGRADING ENZYME

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Amyloid-β protein (Aβ) plays an important role in the pathogenesis of Alzheimer's disease and is the cause of neuronal deaths. Oxidized Aβ and oxidatively crosslinked were examined to see if they were less susceptible to protease digestion by IDE, a major Aβ-degrading enzyme and compared to digestion by the more general protease, trypsin. $A\beta_{40}$ and $A\beta_{42}$ peptides were each oxidized with either NBS or Cu^{++}/H_2O_2. Oxidized Aβ peptides were lyophilized and resuspended and then desalted using C18 spin columns. A BCA protein assay was sued to determine the recovery of Aβ from the columns.

Non-oxidized and oxidized Aβ_{40} and Aβ_{42} were subjected to proteolysis with IDE or trypsin. Aβ samples were electrophoresed and were analyzed by Western Blot and the results were captured on x-ray film. The conclusion for the experiment was trypsin is able to digest unoxidized Aβ_{40} and Aβ_{42} but not the oxidized samples. IDE wasn't able to digest the unoxidized and the oxidized sample, which was a deviation from previous research, which have shown that IDE is able to degrade unoxidized Aβ. This deviation may be due to problems with the IDE or IDE's activity with the Aβ_{40} and Aβ_{42}.

128. DETECTING SNPs IN EXON 1 OF THE *HOXA10* GENE OF CRYPTORCHID PATIENTS

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Cryptorchidism is the testicular maldescent in male infants. *HOXA10* is a homeobox gene that regulates gene expression and differentiation. Disruptions of the mouse homologue of this gene, *Hoxa10,* cause cryptorchidism. It is proposed that disruptions in *HOXA10* predispose human males to cryptorchidism. Abnormal *HOXA10* gene expression is caused by genetic polymorphisms. The goal of this study is to detect for polymorphisms in exon 1 of the *HOXA10* and associate them with cryptorchidism. DNA was extracted from human blood from cryptorchid subjects in a study at USC. Control cases amplified products in exon 1 by PCR, using oligonucleotide primers. The DHPLC analysis screened DNA fragments for SNPs. An elution profile for the DNA fragments show heterozygous or homozygous profiles, identified by peak formation on the chromatograms; heterozygous profiles indicate polymorphism(s). Control DNA samples were run under non-denaturing conditions; a possible deletion was detected. Verification via analysis by DHPLC and sequencing needs to be done. Thus, analysis of samples from cyptorchid boys was not initiated due to incomplete verification. As a member of the homeobox gene family, the primers of *HOXA10* (comprised Hox proteins) may dimerize with DNA, leading to amplification of sequences of other HOX genes, causing complications in specific amplification for this study.

129. PHAGOCYTOSIS AND CYTOTOXICITY OF NICKEL OXIDE

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Lung cancer kills more individuals than any other leading cancer in both women and men. Not only does lung cancer metastasize as it progresses to its advanced stage, lung cancer is also associated with nose cancer, larynx cancer, prostate cancer, and other cancers. Although lung cancer is predominantly caused by smoking in 87% of its cases, the exposure to carcinogens, such as nickel can also increase the likelihood of achieving lung cancer. Nickel has been believed to be a cause of nasal and lung cancer in nickel refinery workers exposed to these compounds. By studying the induction of phagocytosis and cytotoxicity transformation by insoluble nickel compounds, Nickel Oxide and QNi Nickel compact were compared against their toxicity in C3H/10T1/2 Cl 8 (10T1/2) mouse embryo fibroblasts. After supplementing cells with concentrations ranging from .1325 μM.mL for Nickel Oxide (NiO) and QNi Nickel Compacts (QNiC), cells revealed that they were more susceptible to phagocytocize NiO. The uptake of these nickel compounds also caused programmed cell dead (apoptosis).

130. HIPPOCAMPAL EXPRESSION OF BDNF 5′ EXONS IN AGED FISHER RATS

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Brain-derived neurotrophic factor (BDNF) is part of the neurotrophin family, and has been implicated in the enhanced survival and function of developing and mature neurons. The rat BDNF gene contains four promoter regions, each of which generates a unique transcript form containing one of four 5′ exons and a common 3′ exon. The tissue for this study was taken from two trials, 2 and 14 days in length, in which aged Fisher-344 rats were subjected to daily intraperitoneal injections of the antidepressant tranylcypromine or saline (control). Half of the tranylcypromine and saline-treated rats were provided with running wheels, and the other half was sedentary (control). Relative exon mRNA expression levels were assayed with ^{35}S-labeled riboprobes on cryostat-sectioned tissue. The autoradiographic films were analyzed for each of the five distinct regions of the hippocampus and the four 5′ exons. Expression of the 5′ exons increased markedly with antidepressant treatment, and also when exercise was included. The sedentary rats that received saline had the lowest BDNF expression levels. As each exon is linked with a different promoter region, their differential expression could shed light on the mechanism of BNDF activation by exercise.

131. EFFECTS OF PHOSPHATE ON THE BIOLOGICAL PROCESSES OF TRICHODESMIUM

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The marine cyanobacterium *Trichodesmium* occurs throughout the tropical and subtropical oceans. These bacteria are unusual in their ability to convert atmospheric nitrogen into ammonium while undergoing photosynthesis and are responsible for the majority of the nitrogen supply in the open oceans. In exploiting their ability to fix nitrogen, the use of the oceans as a carbon dioxide sink can be maximized, helping to alleviate global warming. This research focused on the role of phosphate in the biological processes of *Trichodesmium* and its effect as a limiting nutrient. It is postulated that *Trichodesmium* has the ability to hydrolyze inorganic molecules to obtain an additional source of phosphorous, known as alkaline phosphatase activity (APA). This experiment tests *Trichodesmium's* APA response in 6 different phosphate concentrations with an inorganic molecule, 4-methylumbelliferyl phosphate (MUF-P). An inverse relationship between the phosphate concentrations and the amount of MUF-P hydrolyzed was found, confirming the theory that the cyanobacterium has the ability to provide itself with additional phosphorous, should the need arise. The experiment also analyzed the relationship between the concentration of phosphate available and the nitrogen fixing ability of *Trichodesmium.* Using the acetylene reduction process, a direct relationship between the two components was found, verifying the role of phosphate as a limiting nutrient. A better understanding of the role that phosphate plays in maintaining a elemental balance in the open oceans is essential in implementing the use of the oceans as a biological sink for carbon dioxide, thus lessening the major threat that global warming currently presents

131a. GENE MUTATION IN DYDKERATOSIS CONGENITA- STUDY OF EXON 8

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Dyskeratosis congenita (DKC) is an x linked disease which affects only males. Its symptoms are dystrophy of the nails, leukoplakia in the mucus membrane, and often anemia. The goal was to find a discrepancy in the DNA base pairs in order to find the mutation or the cause of *dyskeratosis congenita.* A blood sample was obtained for a research from a patient diagnosed with this disease. Three stages took place in this experiment: PCR, DNA sequencing, and then BLAST. First, the DNA samples were put through PCR (Polymerase-Chain Reaction) to create copies. The primers ordered were specially used to amplify the DKC gene only. Then, an electrophoresis gel was run to find the right sized exon. The gel uses positive and negative poles to allow samples to be pulled across its porous surface. The size of the exon that was necessary was four-hundred base pairs. UV rays, in the transilluminator were used to find the PCR products of the gel. The DNA sequencing was done by creating a much larger gel, and color coding each base pair. Then a laser was able to read which specific base pair was in the exon. This printed out the base pairs in exon 8. Next we used BLAST, a DNA database program from GenBank to check for mutations. The sample of exon 8 in the patient's DNA, was found to not contain a mutated base pair. This finding has enabled us to start checking other exons to narrow our future search.

132. SYNTHESIS OF PALLADIUM NANOWIRES BY ELECTRODEPOSITION ONTO HIGHLY ORIENTED PYROLITIC GRAPHITE

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Palladium nanowires of diameters ranging from 62.9 to 159 nm were synthesized by electrodeposition onto highly oriented pyrolitic graphite. Variables of nucleation times, nucleation potentials, and deposition potentials were adjusted to produce the most structured nanowires. Based on the third scan of a cyclic voltammagram, it was hypothesized that the deposition potential be approximately .400 V. Following this, palladium nanoparticles were deposited under selected conditions onto graphite via step-edge decoration, forming nanowires along the step-edges of the crystalline surfaces. By adjusting the nucleation times, nucleation potentials, and deposition potential, unwanted deposition onto the basal plane was minimized, and structured nanowires formed. After repeated trials it was concluded that a deposition potential of .370 V, a deposition time of 1200s, and a nucleation time of 6 ms resulted in optimal wire growth.

133. THE CHEMICALLY DEFINABLE DIFFERENCES BETWEEN A WATER WASH AND NON-WATER WASH SYSTEM IN ANAYLSIS OF WATER CONTENT

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The water wash process used to cleanse Bio-diesel fuel was compared to a non-water wash system composed of an investigative media. Research describes the media as polymer beads that stripped the fuel of water and glycerin molecules as well as reduced the pH level. Samples of tap water (control), water wash oil (independent variable), and non-water wash oil (dependent variable) were tested using a filter methodology with a ratio of the media to the specific liquid substance (50 g: 100 ml). A combination of synchronized temperature markings determined the exothermic reactions in each sample and a weight system measured the absorption rate the media had on each liquid. Subsequent to the testing of the non-water wash using the media, virgin batches of soy oil were processed through the water wash and a designed apparatus operating on the non-water wash system. Results indicated the non-water wash to be without absorption of water, while the water wash contained a significant level of water content. The collected data showed promising results to further testing with regards to an experimental design and randomized data in order to fully understand the entirety of the two processes.

134. ALGORITHM PERFORMANCE ON THE SATISFIABILITY PROBLEM

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The satisfiability problem is very important because of the NP-complete nature of the problem. By generalizing an efficient way to solving this problem, it can be applied to problems that have the same NP-complete property.

The Satisfiability problem consists of clauses and variables. The variables have two solutions: True or False. Clauses comprise of variables connected through OR operators. In some cases, NOT operators are situated at the front of variables. They are used to negate variables. All clauses are further linked to one another using AND operators.

Using three algorithms, a comparison was done to see which algorithm proved to be most efficient when dealing with a range of satisfiability problems. The genetic algorithm creates a population of solution sets and hybridizes them depending on their fitness level. The hillclimbing algorithm generates a random solution set and manipulates it to fit the constraints set by the clauses. The simulated annealing algorithm is a variation to the iterative improvement algorithm, but allows for moves that are less satisfiable to the problem in an attempt to find a more satisfiable solution thereafter.

Due to the diversity of satisfiability problem, the experimentation was divided into three categories: satisfiable problems, unsatisfiable problems, and unknown problems. Satisfiable problems had a clause to variable ratio of 1:1. Unsatisfiable problems had a ratio of 10:1. Unknown problems had a ratio of approximately 4.25:1.

135. DESIGN AND CREATION OF A LOW-COST VOLUMETRIC DISPLAY DEVELOPMENT SYSTEM

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A Volumetric Display System was designed and created using a rotating helical screen, based on the concept of R. Hartwig, using the RCX microprocessor, components, and bricks made by LEGO, a fiberglass screen, and a common laser pointer. The helical screen was constructed from transparent resin applied to fiberglass cloth fitted to a helical mold. Various combinations of gears were used to determine the optimal rotational speed of 3 times per second, giving a 3Hz refresh rate at approximately 7500mV to 9000mV of voltage. Numerous programs and computer functions were created to control such variables as motor rotation speed, laser pulse rate, laser pulse length, among others with the RCX's default firmware, an alternative programming language known as NQC, and the BrickCC IDE. The setup proved effective in projecting stationary voxels in the 3D medium as well as multiple pixels at the same time. Due to a lack of outputs, an X-Y positioning system was not implemented.

136. MICROBIAL RESPONSE TO EXPOSURE FORM VARIOUS STRESSORS

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Infections with gram-positive, gram-negative, and fungal organisms resistant to multiple antibiotics are an emerging clinical problem. Although humans employ several stress mechanisms to prevent and limit the microbial colonization, distinct types of microbial diseases cause destruction of body tissues, blood clotting, and *Typhoid fever.* This study involves several types of biochemical stresses such as oxidation, membrane injury, osmotic stress, and DNA damage that were introduced to determine the concentration at which they were inhibited. This was done by finding **M**inimal **I**nhibitory **C**oncentration and **M**inimum **M**icrobicidal **C**oncentration methods. The results indicated that Bacteria and Fungi had significantly different stress resistance when grown in minimal nutrient and complex nutrient media. Indicating that he amount of stress used affect the organism, but also the environment plays a key role. It was significant to find out that the gram-positive *Staphylococcal* strains, found on the skin, were least affected by *Sodium chloride* in Muller Hinton Broth, a complex medium containing tissue from the brain and heart of a cow, while Nutrient Broth was most affective with *Sodium chloride.* Air bubbles of Oxygen seen as a byproduct on plates may have contributed to the way stress affected the organisms and resulted from the degradation of *Hydrogen peroxide* by catalase. This means that *Hydrogen peroxide* was reaching high levels in the bacteria and the bacteria were reacting by catalyzing it into less harmful, and useful, by-products. Although the stressors are simplistic, the result will be taken by pharmaceutical companies to be used in and combined with antibiotics.

137. STRAIN RELATEDNESS OF *CANDIDA* IN HUMANS: A URINARY PATHOGEN OR COLONIZER?

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Candida species in the urine of hospitalized patients (candiduria) is a very common occurrence among hospitalized patients with over 50,000 cases complicating hospitalizations annually. However, the clinical significance of candiduria remains controversial as there is evidence that this may represent a potentially serious and deadly infection that may spread to the bloodstream, or, alternately, merely represent urinary tract colonization. To resolve this, samples of urine from over 300 patients from Harbor-UCLA Medical Center were analyzed, and data regarding the patient's fungal infection or colonizations in different body sites, as well as their patterns of uses of antifungal medicines and urinary catheters were recorded. Differences in strains of each Candida infection were examined using traditional speciation methods as well as molecular techniques (DNA fingerprinting). The results of this experiment show that *Candida* in the urine commonly resolves spontaneously (97.4% or specimens) and can recur with either the same Candida strain (76.3%), or a different strain (23.7%). Furthermore, patients with Candiduria and Candidemia were more likely to lack strain relatedness (88.9%) than have strain relatedness (11.1%). Finally, antifungals did not have any effect on the persistence (3 versus2.446) nor the recurrence (2.67 versus 2.53) of fungal infections. Consequently, *Candida* in the urine among hospitalized patients does not appear to be associated with serious *Candida* bloodstream infections. Candiduria infectants tend to wax and wane with time, and occasionally are supplanted with other *Candida* strains. This suggests that most *Candida* strains have low pathogenicity in hospitalized patients and may not require treatment.

138. DETERMINATION OF BACTERIAL AND POLLUTANT FLOWS IN COASTAL ESTUARIES OF SOUTHERN CALIFORNIA

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There are two main objectives of this experiment: to create a mathematical model showing the relationship between turbidity, dissolved oxygen, pH, and levels of indicator bacteria for fecal contamination and to assess the impact of the Ballona Wetlands on coastal ocean waters. In the field samples were tested for temperature, dissolved oxygen, and pH levels using the YSI 600R Sonde Electronic Probe. Further testing was done in the lab using the HACH 2100N Turbidimeter for turbidity levels and IDEXX Quantitray 2000 System with the MPN method for levels of indicator bacteria. A mathematical model was created showing the relationship between dissolved oxygen (dO), turbidity (T), pH, and bacterial growth (EB), where K is the constant of proportionality.

	$[EB] = \kappa e^{|7 - pH|}([dO][T])^2$
K (Total *Coliform*)	2.00×10^{1} MPN·DL/mg^2·NTU
K (*E. Coli*)	1.06×10^{-1} MPN·DL/mg^2·NTU
K (*Enterococci*)	8.79×10^{-3} MPN·DL/mg^2·NTU

Results indicated that bacterial levels were higher with increased turbidity and dissolved oxygen in a neutral pH. These results clearly show correlation with increase in suspended solids (increase turbidity) with bacterial levels as can occur with rain storms. Total *Coliform* levels were also higher during the flood tide than the ebb tide seventy percent of the time because flood tides may cause an increase in suspended matter and ebb tides carry bacteria out of the wetlands. This study shows that sophisticated mathematical models can be constructed to greatly simplify the current testing procedures and be more cost-effective. This model will prove critical from an economic point of view and from beach safety considerations.

139. ENVIRONMENTAL INFLUENCE ON THE CLONING RATES OF METRIDIUM SEA ANEMONES

Kevin McCully. 28320 Coveridge Dr., Rancho Palos Verdes, CA, 90275

The purpose of my experiment is to determine if different external environmental factors, which simulate different natural habitats, affect the reproduction rates of *Metridium* sea anemones. *Metridium* sea anemones were chosen since in an aquarium tank they reproduced very fast (probably by cloning) and were happily attached to any surface. My hypothesis was that environment would affect the cloning rates and I wanted to measure the effects of more food (immature brine shrimp), increased circulation, and reduced light. I tested cloning rates with nine tanks having their own water supply; each tank was divided in two with a plastic mesh placed in the middle. One sea anemone was placed in each half tank. Four half tanks received extra feeding, four had double the circulation, and four had reduced lighting. I also had six half tanks with the nominal conditions, meaning they got fed three times a week, had a set circulation, and constant light. I hypothesized that more food would increase cloning rates, that more circulation would increase cloning rates, and that less light would decrease cloning rates. Unfortunately, my results were not statistically significant, perhaps due to experimental difficulties (such as inconsistent water circulation which resulted in dirty tanks, possibly not seeing the anemones, and movement of the anemones). However, my results did show that, on average, dark tanks had more cloning, but extra food tanks and circulation tanks had less growth than the control tanks. I hope to continue this experiment using new techniques to minimize the varying circulation conditions.

140. MODELING THE DISTRIBUTION OF INVASIVE ARGENTINE ANTS IN THE CONTIGUOUS UNITED STATES: EFFECTS OF CLIMATIC FACTORS AND HUMAN HABITATION

G. Y. Williams. Redondo Union High School, Redondo Beach, CA 90277

The Argentine ant, *Linepithema humile,* is one of the world's most aggressive and damaging invasive species. Due to adverse economic and ecological effects of this species, there is considerable interest in predicting how much further *L. humile* might spread. This study investigated *L. humile's* physiological and behavioral characteristics, its two modes of dispersal, and the influence of climatic conditions and human disturbance to construct a predictive model using GRASS software, to show areas of potential *L. humile* invasion in the continental U.S. Maps of average annual temperatures, total precipitation, and population by state counties overlaid with known distributions of *L. humile* show that large areas of the Southeast are subject to Argentine invasion as well as any urban site in favorable or unfavorable climate zones.

141. THE EFFECT OF BODY SYMMETRY ON ATHLETIC ABILITY

Nicole Young. 5826 Flambeau Rd. Rancho Palos Verdes, CA, 90275

Does body symmetry affect athletic ability? Scientific tests have never proven this to be true, though past studies have correlated symmetry to beauty, survival, and success in breeding. Biology Professor Dr. Jay Phelan has researched human symmetry, and I intend to build on his research and extend it to athletic ability. My hypothesis is that a person with a high degree of body symmetry has more coordination and balance compared to the average person therefore making them more athletic. This project is designed to test 20 athletic people and 20 non-athletic people and compare the degree of symmetry between the two groups. A precision digital measuring caliper was used to take a total of 32 measurements, (hands, face, knees, ankles, and feet) from the left and right side of each subject. These body parts were chosen because of their equal growth rate on both the right and left sides of the body. Measurements were taken twice and averaged (to reduce measurement errors) and results were used to calculate the symmetry index of each subject. The symmetry index gives a percentage out of 100, 0 being perfectly symmetrical. After adding up the results for the two groups (the non-athletic subjects and athletic subject's) an average index was derived for each group. In conclusion, the results conclusively show body symmetry does have an effect on athletic ability and the higher the degree of body symmetry the more athletic the person.

142. MOTOR DEVELOPMENT IN CHICKEN EMBRYOS

Joanne Siu. Alhambra High School. Mentor: Nina Bradley, USC Keck School of Medicine

Studies of animal behavior and its application to humans such as, using chicken embryos rather then baby's to study the abnormal development during human fetal and neonatal development has been an ever growing interest. Literature has already described the behavior of pre-hatching movements in chicken embryos. However in my project, Motor Development in Chicken Embryos, I use quantitative methods of movement analyses that include motion and muscle activity. I hypothesize that chicken embryos use their beaks, rather then legs to hatch. My hypothesis is base on the theory of Ronald W. Oppenhiem. I placed electromyography electrodes into major muscle of the right wing and leg. EMG and force were recorded on computer and video was taped. I then used computer to measure the EMG activity from leg and wing muscle. I found as a result repetitive movements and came to one of the possible conclusions that chicks may be using leg movements for preparation of hatching. However I don't yet know if they actually use their legs "during" hatching. This project can give researcher new ideas about the significance of leg movements in human fetal development. A better understanding of the biology of embryonic movements can help us to better diagnose medical problems earlier in fetal development.

143. QUANTUM YIELD STUDIES OF SINGLET OXYGEN PRODUCTION BY SQUARE PLANAR COMPLEXES

H. Fong, J. Tang, A. Tran, and M. Selke. California State University, Los Angeles Department of Chemistry and Biochemistry, 5151 State University Drive, Los Angeles, CA 90032

Singlet oxygen, $^1\Delta_g$ of dioxygen, is of great interest to many research groups because of its reactivity with biomolecules including nucleic acids and some amino acids. Our previous research has found that bis-cyclometallated Iridium(III) complexes sensitize the production singlet oxygen in high quantum yields. However, nothing is known whether complexes possessing other metals are also efficient sensitizers. Therefore, the quantum yields of singlet oxygen from a new class of square planar Platinum(II) complexes is of great interest.

The quantum yields of singlet oxygen production and quenching rates of these Platinum(II) complexes are presented. Time-resolved laser spectroscopy was employed in this study. Platinum(II) complexes were excited at 532nm and 355nm wavelengths to generate singlet oxygen. Singlet oxygen decay (luminescence) was detected using a near-infrared luminescence detector and compared with known sensitizer quantum yields to determine the singlet oxygen quantum yields of the complexes. Quenching rates, i.e. the rates of singlet oxygen deactivation, were also measured using laser spectroscopy.

The quantum yields of singlet oxygen of the Platinum(II) complexes are high (0.9–1.0), and quenching rates are slow. When these high quantum yields are compared to the Iridium(II) analogues it can be concluded that the energy transfer from the excited sensitizer to oxygen does occur at the metal center. In all, we have an excellent new class of singlet oxygen sensitizers. Our findings add to the current understanding of metal-centered sensitizers and will provide researchers with a blueprint for the synthesis of new sensitizers for photodynamic therapy.

144. ACCESSING THE EFFECTS OF SLEEP DEPRIVATION IN A LONG LIVED *DROSOPHILA MELANOGASTER* LINE

Anum Sheikh. California Institute of Technology, Benzer Lab, Department of Biology Pasadena, CA

Aging is a process of numerous detrimental changes that are progressive and universal and occur in a variety of biological molecules. Thus, I investigated if there is a relationship between sleep deprivation and lifespan in *Drosophila.* Despite the importance of sleep in our lives and our inability to get enough of it, sleep remains a mystery to researchers. It was recently established that *Drosophila melanogaster* rest has sleep-like behavioral features, including prolonged immobility and preferred resting position. Furthermore, I manually sleep deprived the flies to examine the amount of activity delivered by each. Consequently, I looked at the activity rebound of a long-lived line and its control (the fly line 1064/109 is the long-lived line and 1064/w and 109/w are the controls). Hence, experiment one was performed to analyze the sleep-activity cycles (using the Trikinetics Activity Monitor), where the flies were raised on different levels of nutrients; experiment two used flies raised on different levels of nutrients from experiment one and then further sleep depriving them to determine average activity and finally those flies were used to set up a lifespan analysis in the end. An average of 800 readings were taken by using three different fly strains by the Trikinetics Activity Monitor over a period of three days. It is assumed that one reading was taken every 45 minutes. All five strains exhibit the same period—two of them look nearly identical, while the other strain exhibits, an average, a higher level of activity.

145. ACTIVITIES CHARACTERISTIC OF *DROSOPHILA* LONGEVITY MUTANTS *1101, 1130,* AND *2456*

Anna Lam. Alhambra High School. Mentor: Dr. Horng-Dar Wang, California Institute of Technology

Longevity mutants were confirmed by selective breeding, successful in combining longevity with stress-resistance. By studying these mutants' behavior through different tests, aspects of human aging conditions can become much clearer. Last year's project incorporated the use of microarray analysis to find comparisons and differences of the mutants' genomes in search of biological pathways of the fly's longevity. A more specific approach analyzes the flies' average levels of activity, weight, and metabolism. Negative geotaxis tests revealed a rise in activity levels of longevity mutants compared to that of the wild type. Longevity mutants were also heavier compared to wild types. Even more significant results showed a higher metabolism rate in longevity flies. All results showed a higher possibility of vigor in these longevity mutants, especially inferring a conflicting view to the established theory that organisms with lower metabolism rates live longer. Knowing the characteristics of longevity mutant behavior may shed light on the physical possibilities for human longevity.

146. PROBLEMS WITH *PISTA* IN THE NORTHEAST PACIFIC (ANNELIDA: POLYCHAETA: TEREBELLIDAE)

L.H. Harris. Natural History Museum of Los Angeles County, 900 Exposition Blvd., Los Angeles, CA 90007

Identification of species in the genera *Pista* Malmgren, 1866, and *Betapista* Banse, 1980, in the northeast Pacific has been problematical despite recent revisions. Type material, specimens cited in original descriptions, and supplemental specimens have been reviewed to resolve this situation. The genus *Betapista* belongs to the subgroup of *Pista* species with multiple nephridia in the thorax and enlarged anterior neurohooks. Members of *Pista sensu strictu* have 2 pairs of thoracic nephridia and neurohooks of equal size throughout the thorax. *Betapista* is redefined, and *P. elongata* Moore, 1909, *P. moorei* Berkeley & Berkleley 1942, and *P. pacifica* Berkeley & Berkeley, 1942, are moved into this genus. A complex of morphologically similar species along this coast includes *Pista agassizi* Hilbig, 2000, and two new species. *P. percyi* Hilbig, 2000 is considered to be a junior synonym of *P. agassizi.*

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SOUTHERN CALIFORNIA ACADEMY OF SCIENCES

CALL FOR PAPERS

2005 ANNUAL MEETING

May 20–21, 2005

LOYOLA MARYMOUNT UNIVERSITY

LOS ANGELES

Contributed Papers & Posters: Both professionals and students are welcome to submit abstracts for a paper or poster in any area of science. Abstracts are required for all papers, as well as posters, and must be submitted in the format described below. Maximum poster size is 32 by 40 inches.

The Southern California Academy of Sciences will hold its annual Meeting for 2005 on the campus of Loyola Marymount University Friday and Saturday May 20–21.

Presently the following symposia are in the planning stages. If you would like to organize a Symposia for this meeting, or have suggestions for a symposia topic, please contact John Dorsey at jdorsey@lmu.edu. Organizers should have a list of participants and a plan for reaching the targeted audience.

Proposed Symposia

Wetlands Ecology: Ralph Appy (rappy@portla.org)

Southern California Archaeology: Andrea Murray (amurray@exchange.fullerton.edu)

Ecology of Nearshore Reefs: Daniel Pondella (pondella@oxy.edu) and Bob Grove (grovers@sci.com)

Avian biology: Kathy Keane (keanebio@cs.com)

Southern California Paleontology: Mark Roeder (mroeder1@earthlink.net)

Interface between Ecology, Sociology and Geography in the Los Angeles Basin: Jim Faught (jfaught@lmu.edu)

Watersheds and Pollution: Kenneth Schiff (jima@sccwrp.org)

There will be additional sessions of Invited Papers and Posters and of papers by Junior Academy members.

Abstracts of presented papers and posters will be published in the August issue of the Bulletin.

Student Awards: Students who elect to participate are eligible for best paper or poster awards in the following categories. Biology: ecology and evolution, biology: genetics and physiology, physical science. A paper by any combination of student and professional co-authors will be considered eligible provided that it represents work done principally by student(s). In the case of an award to a co-authored paper, the monetary award and a one year student membership to the Academy will be made to the first author only.

For further information on posters, abstracts, registration and deadlines, see the Southern California Academy of Science web page at: www.lam.mus.ca.us/~scas/

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Status of Nesting Ospreys in Coastal Baja California, Sonora and Sinaloa, Mexico, 1977 and 1992–1993.

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Abstract.—We used a double-sampling technique (air + ground surveys), with partial double coverage and an additional adjustment for lack of nesting synchrony in southern latitudes, to estimate the size of the osprey (*Pandion haliaetus*) nesting population in the study area in 1992–1993. The osprey population was previously surveyed in 1977 by the same authors, although their published findings were not adjusted for early or late nests missed. An estimated 810 ± 55 (95% C.I.) pairs were nesting at the *time of the aerial survey* in 1977, but the population increased 68% to an estimated 1,362 ± 278 pairs at the *time of the aerial survey* in 1992–1993 (Baja California surveyed in 1992, Sonora and Sinaloa in 1993). The new adjustment for nesting chronology to estimate the total nesting population (including early and late nests missed) adds 19% to the *time of the aerial survey* population estimates for both 1977 and 1992–1993. The surveyed area was divided into seven regions for summary purposes in 1977; the same as in 1992–1993. The distribution of nesting pairs was similar during both time periods, except two range expansions to the north, which we attributed to the presence of artificial structures in flat terrain with no suitable cacti. The estimated number of nesting pairs on the Pacific side of Baja California (focused on Scammon's and San Ignacio Lagoons) more than doubled, while the population did not increase on the Gulf of California side of Baja California. Osprey pairs nesting on the Midriff Islands in the Gulf of California increased 64%—those nesting on islands nearer Baja California remained generally the same, and those on islands nearer Sonora showed the most increase. The nesting population in Sonora and Sinaloa also more than doubled with a higher rate of increase in Sinaloa. The use of human-made structures for nest sites is still small (only 6%). This population still nests primarily on cliffs (40%), cacti (37%), and the ground (16%).

Seventy-six years ago the osprey (*Pandion haliaetus*) was reported as a common coastal resident along both the Pacific and Gulf sides of Baja California and practically all the adjacent islands (Grinnell 1928). Based on field surveys in 1977, the first regional nesting population estimate was made with about 174 pairs along the Pacific side of Baja California, 255 pairs along the Gulf side, 187 pairs on the Midriff Islands and 194 pairs in coastal Sonora and Sinaloa (Henny and Anderson 1979). The objective of this report was to compare the distribution and abundance of ospreys breeding in 1977 with our findings in 1992–1993 when we repeated the survey. Other local studies were also incorporated into our overall assessment.

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Methods

We subdivided our large study area into seven regions: basically a northern and southern portion of both the Pacific Ocean side and the Gulf of California side of Baja California, the Midriff Islands in the middle of the Gulf of California, and coastal Sonora and coastal Sinaloa. We made a single pass along the shore to census rocky or sandy cliffs adjacent to the shoreline or flat terrain with no cacti. In areas where large cactus or mangrove forests existed near to the shoreline, we flew transects at increasing distances landward from the shore looking for osprey nests until no more were observed. Generally, we did not find nesting pairs more than 2 km landward from the shoreline (the two most inland nests we located were 7 and 9 km inland, both near Scammon's Lagoon and on human-built structures).

We located osprey nests in 1992–1993 from a twin engine fixed-wing aircraft with excellent visibility and a Global Positions System (GPS) (Partenavia PN68TC). The survey was flown at an altitude of 60–100 m between 20 March and 2 April. Coastal Baja California and adjacent islands were surveyed in 1992, but a factory recall of an engine part (aircraft had just received new engines) during the survey delayed our aerial survey of coastal Sonora, Sinaloa and adjacent islands until 1993. The GPS allowed us to record the location of each occupied nest in 1992 and 1993. No GPS was available during our 1977 survey which was flown at the same time (24 March to 1 April). A pilot and two observers (same as in 1977, CJH and DWA) were present in the plane, and about 80 h of flying time were logged during both surveys.

We classified nests observed during the aerial survey as occupied if an adult was present on or in the immediate vicinity of the nest, or if young/eggs were seen in the nest. An attempt was made to schedule the aerial survey during the peak of the nesting cycle, although the season is not well synchronized in southern latitudes (but see nesting chronology below). Occupied nests would have been missed if a bird was not at or near a nest when it was surveyed, the nest was abandoned before the area was surveyed, the nest was initiated after the area was surveyed, or we failed to see the nest. Unoccupied nests were also recorded.

Since it is costly and time-consuming to conduct the ground or boat survey of the double survey, we surveyed all of the study area by air but covered about 7–8% of the population from the ground, to develop a partial double-survey population estimate and its associated variance. The ground studies, conducted by individuals involved with other studies, were generally made by boat, although one area was surveyed on foot and from a pickup truck. The ground studies were conducted within a few days to 2 wks of the interval for the aerial survey, and made it possible to compare numbers of occupied nests at the time of census in various areas seen from air, ground, and both air and ground. Comparing data from both counts allowed us to obtain a visibility rate for adjusting aerial counts to the total nesting population at the *time of the aerial survey* by use of a modification of the Petersen Estimator (see Henny and Anderson 1979). We sampled a finite population of size N (N unknown) by use of the two methods. The data were then recorded so that we knew the number of elements s_a, observed by

Table 1. Number of occupied osprey nests (nesting pairs) seen from the air and the ground.

Year nest substrate	Air (s_a)	Ground (s_g)	Both (m)	Total est. (N)	Visibility rate (N/s_a)
1977					
Cliffs	88	121	74	143.89	1.64[a]
Cactus	7	9	6	10.50	1.50
Cliffs & Cactus (combined)	95	130	80	154.38	1.63
Scammon's Lagoon (ground nests)	26	23	22	27.18	1.05
1992, 1993					
Cliffs (LA Bay)[b]	32	43	25	55.04	1.72
Cactus (Kino)	16	27	16	27.00	1.69
Cliffs & Cactus (combined)	48	70	41	81.95	1.71

[a] Values for three locations sampled in 1977 were 1.54, 1.75 and 1.77.

[b] Combined information for both 1992 and 1993.

method 1 (aerial survey), the number of elements s_g, observed by method 2 (ground survey), and m, the number of elements observed by both methods. Then,

$$\hat{N} = s_a s_g / m$$

is a reasonably good estimator of N. In this approach we assumed statistical independence of s_a and s_g.

In sampling osprey nests, it was also necessary to assume N was not changing during the time between the ground and air survey. With the ground and aerial counts made within 2 wks of one-another, it is doubtful that significant changes had taken place. Then $\hat{N}/s_a$ is a reasonably good estimator of the aerial Visibility Rate. The aerial count was multiplied by the aerial Visibility Rate to obtain population estimates for areas with only aerial counts. Separate Visibility Rates were initially estimated for nests in cacti, nests on cliffs, and ground nests on small islands. For this study, the nests on cliffs and cacti were combined because of their similar Visibility Rates (Table 1). A comparison of the maximum number of occupied nests seen from both air and ground with the estimated number of nests (N) occupied at the *time of the aerial survey* suggests that about 6.1% in 1977 and 3.6% in 1992–1993 were undetected by both air and ground counts. Visibility Rates for cliffs and cactus (combined) in 1977 and for this survey in 1992–1993 were similar (1.63 and 1.71), which suggests that the Visibility Rate had minimal influence on the percent change in the osprey population estimates.

Scammon's and San Ignacio Lagoon and vicinities included large numbers of ospreys in 1992 in relatively small areas. Therefore, we relied upon detailed counts throughout the nesting season of those areas by Castellanos and Ortega-Rubio (1995) and Castellanos et al. (1999) from 1993, and Danemann (1994) from 1989. These two lagoons accounted for 20% of the osprey population in our study area and were treated as total counts. For the other portions of the study area, nests occupied at the *time of the aerial survey,* but believed to have been missed by both air and ground surveys, were included in estimates presented here. However, occupied nests abandoned before the survey, or initiated after the survey, are not included in our initial population estimates (but see nesting chronology below). No Visibility Rates were available for nests in mangroves; therefore, the combined value for cacti and cliff nests was used. We believe nests in mangroves were more difficult to locate from the air, thus, nesting pairs in mangroves in coastal Sinaloa and perhaps Magdalena Bay (although none were located) may be underestimated. In the text, we refer to *observed* occupied nests (nesting pairs) when raw counts are used and *estimated* occupied nests (nesting pairs) when Visibility Rate adjusted counts are used. For simplicity in the text, we will refer to either observed nesting pairs or estimated nesting pairs.

The variance estimate was not detailed in our earlier report (Henny and Anderson 1979), but is described below. Let there be two similar areas with populations of sizes N, and M. It is assumed that the aerial visibility of nests is the same in both areas. In one area both air and ground counts are made. A critical assumption is that the air and ground counts are statistically independent. In the second area only aerial counts are made.

Using the following notation:

N	population size in area covered by ground and air
M	population size in area covered by air only
s_a	nests seen by air in air-ground area
s_g	nests seen by ground in air-ground area
m	nests seen by both air and ground methods
C	aerial count of nests outside of air-ground area, a binomial random variable
T	= N+M, population total

Estimation formulae used in the study were:

$$\hat{N} = s_a s_g / m \qquad \hat{M} = C s_g / m \qquad \hat{T} = \hat{N} + \hat{M}$$

The variance comes from the theoretical formula for the Lincoln-Peterson estimator.

$$\hat{V}(\hat{N}) = \frac{\hat{N}}{m}[\hat{N} - (s_a + s_g - m)]$$

The covariance was obtained by another large sample method often called the delta-method.

$$\widehat{\mathrm{Cov}}(\hat{N}, \hat{M}) = C\hat{V}(\hat{N})/s_a$$

$$\hat{V}(\hat{M}) = \frac{C^2}{m}\left(\frac{s_g - m}{m}\right)\left[1 + \left(\frac{s_g - m}{m}\right)\right] + \hat{M}\left(\frac{s_g - m}{m}\right)$$

$$\hat{V}(\hat{T}) = \hat{V}(\hat{N}) + \hat{V}(\hat{M}) + 2\,\widehat{\mathrm{Cov}}(\hat{N}, \hat{M})$$

To obtain the overall total estimate and its variance, we add the individual estimators $\hat{T}$ and $\hat{V}(\hat{T})$ over all strata. The estimated standard error (SE) of $\hat{T}$ is thus $\sqrt{\hat{V}(\hat{T})}$.

It would be useful to provide an estimate of the variance associated with the seven regional estimates. This can be accomplished by assuming that the relative variance by region is the same as that for the total population. So, if the total has $\hat{N}$ and SE, obtain CV = SE/$\hat{N}$ and for any subset of the data with estimated population size X, take its SE to be: SE(X) = X*CV. For this study, CV = 0.1019. Such SE's on $\hat{N}$ by region would be useful, but not perfect. $\hat{N}$ ± 95% C.I. for each region in 1992–1993 are shown in the last table presented.

Table 2. Number of occupied Osprey nests from ground counts at Ballena Islands, San Ignacio Lagoon, Mexico, 1989 (summary from Danemann, pers. comm.).

Time period	Number occupied nests South section	North section	Total
13–18 Jan	41	10	51
6–13 Feb	86	16	102
15–21 Feb	100	19	119
8–15 Mar	100	22	122
17–23 Mar	98	22	120[a]
7–14 Apr	77	21	98
16–22 Apr	71	19	90
3–9 May	35	16	51
4–13 June	9	2	11
Total Occupied (Whole Season)	110	33	143

[a] Most closely relates to time period of aerial survey with 120/143 = 83.9% of total nests occupied at that time, or an adjustment factor of 1.19 (143/120).

Generally, in more northern latitudes where this type of survey approach was first conducted (Henny et al., 1974; Henny and Noltemeier, 1975), the nesting cycle was synchronized; however, this synchrony does not occur in Mexico. Jehl's (1977:243) statement citing Kenyon (1947) regarding ospreys in Scammon's Lagoon is typical, "nests there contained all stages from fresh eggs to flying young." Henny and Anderson (1979) noted that more research on nesting season chronology was needed throughout the study area to evaluate what percentage of the total breeding population was nesting at a certain time, and that a further refinement may be made of the population estimate obtained from the earlier study and subsequent studies. To better address the issue of survey timing and nest occupancy in the region, we used detailed studies of ospreys in San Ignacio Lagoon (26°54′ N; 113°09′ W) by Danemann (1994). He provided information on the number of nests occupied on two small islands (Ballenas) between mid-January and early June 1989 (Table 2). Our surveys in late-March approached the peak of occupancy, although only 83.9% of the total nests occupied for the season were occupied at that time. Because of this lack of nesting synchrony, there would be no survey time when all nests for the year were occupied. A final adjustment of population estimates for both the 1977 (not previously adjusted for lack of nesting synchrony) and 1992–1993 will be made here based upon this new information, and the double-adjusted estimates (for birds missed that were nesting at the *time of the aerial surveys* and for those nesting earlier or later) will only be presented in the last Table. Future studies may show variability in nesting chronology among regions, but only one detailed chronology dataset currently exists. The same adjustment for nesting chronology was used for all regions and both survey time periods (1977 and 1992–1993). The double-adjustment for asynchrony of nesting does not influence the percent change over time, but only total population estimates.

Results

Distribution and Abundance

Using seven designated regions, we summarize our results as follows:

Northwest Baja California, L.C.—The region extends from the U.S.-Mexico

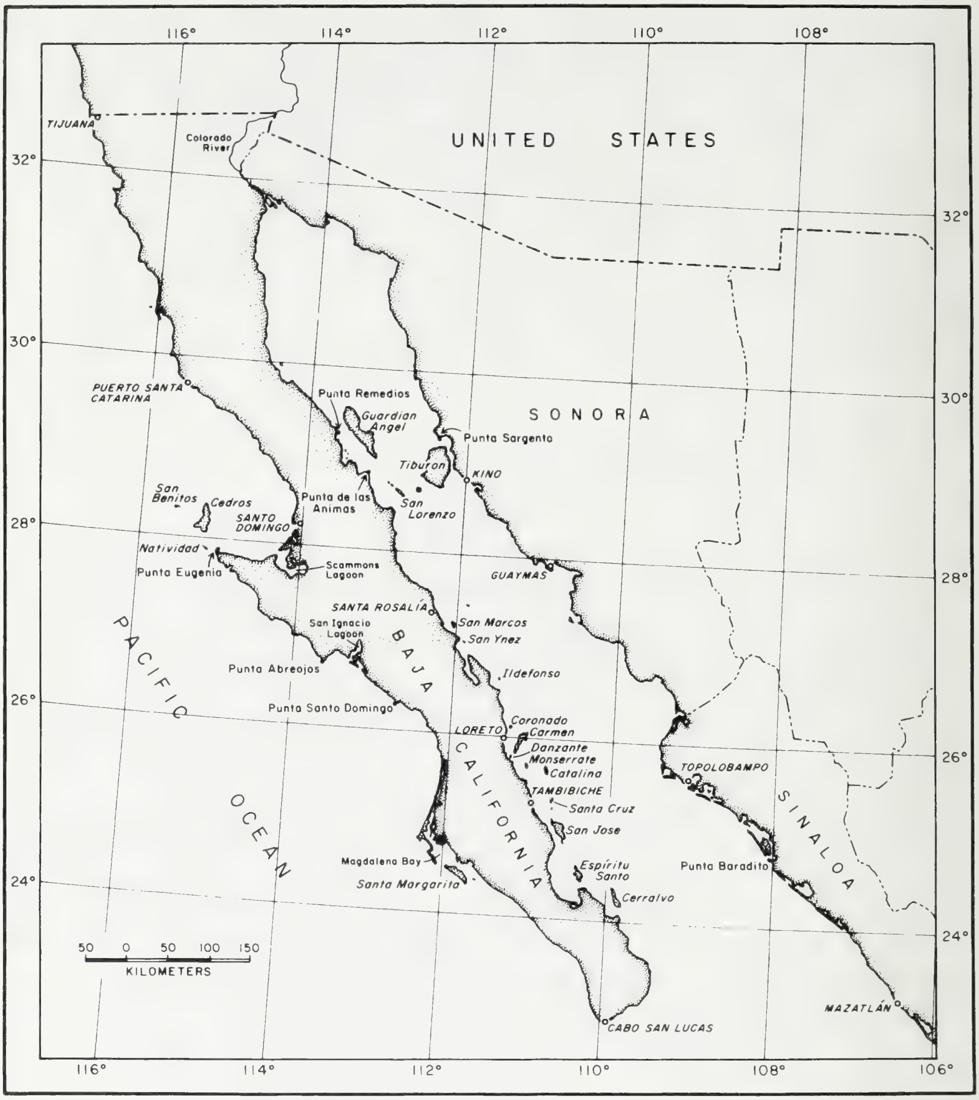
116°
114°
112°
110°
108°
106°
32°
30°
28°
26°
24°
UNITED STATES
TIJUANA
Colorado River
PUERTO SANTA CATARINA
Punta Remedios
Guardian Angel
Punta Sargento
SONORA
Tiburon
KINO
San Benitos
Cedros
Punta de las Animas
San Lorenzo
SANTO DOMINGO
Natividad
Punta Eugenia
Scammons Lagoon
GUAYMAS
SANTA ROSALIA
San Ignacio Lagoon
San Marcos
San Ynez
PACIFIC
BAJA
Ildefonso
Punta Abreojos
Punta Santo Domingo
Coronado
LORETO
Carmen
Danzante
Monserrate
Catalina
TOPOLOBAMPO
CALIFORNIA
TAMBIBICHE
Santa Cruz
San Jose
SINALOA
OCEAN
Magdalena Bay
Santa Margarita
Espiritu Santo
Punta Baradito
Cerralvo
50 0 50 100 150
KILOMETERS
MAZATLAN
CABO SAN LUCAS

Fig. 1. The Baja California and Gulf of California study area for ospreys.

border south to and including Scammon's Lagoon, and west to Punta Eugenia, including Natividad, Cedros, and San Benitos Islands (Fig. 1). The San Benitos Islands were not surveyed in 1977, although population information for 1973 was available. The total population in the region was estimated at 138 nesting pairs in 1977, but increased to 227 pairs in 1992 (Table 3). No nesting pairs were observed between the border and Desembarcadero de Santa Catarina in either 1977 or 1992. The first nesting pair was observed near Santa Catarina at 29° 35′ N; 115° 22′ W. However, from this point south to Morro Santo Domingo, an estimated 20 pairs were nesting on cliffs in 1977, but 31 pairs were nesting in 1992.

Scammon's Lagoon has been part of the El Vizcaino Biosphere Reserve since

Table 3. Distribution and abundance of occupied opsprey nests at the *time of the aerial survey* on the Pacific side of Baja California in 1977 and 1992.

	1977[a]	1992					
Location	Total estimate	Cliff	Cactus	Ground	Other	Max. observed	Total estimate
Northwest Baja, L.C.							
Puerto Santa Catarina to Morro Santa Domingo	19.5	30.8	—	—	—	18	30.8
Scammon's Lagoon and vicinity	50.1	—	—	68.0[b]	58.0[b]	126[b]	126.0[b]
Punta Mallarrimo to Punta Eugenia	—	5.1	3.4	—	1.7	6	10.2
Natividad Island	22.8	8.6	—	—	—	5	8.6
Cedros Island	19.6	18.8	—	—	—	11	18.8
San Benitos Islands	26.0[c]	32.5	—	—	—	19	32.5
Subtotal	138.0	95.8	3.4	68.0	59.7	185	226.9
Southwest Baja, L.C.							
Punta Eugenia to Punta Abreojos	1.6	3.4	—	—	1.7	3	5.1
San Ignacio Lagoon	27.3	—	—	143.0[d]	—	143[d]	143.0[d]
Punta Santo Domingo to Cabo San Lucas	6.5	13.7	29.1	—	6.8	29	49.6
Subtotal	35.4	17.1	29.1	143.0	8.5	175	197.7
Grand Total	173.4	112.9	32.5	211.0	68.2	360	424.6

Note: No adjustment of aerial survey population estimates was made here from nesting chronology.

[a] From Henny and Anderson (1979).

[b] From Castellanos and Ortega-Rubio (1995) and Castellanos et al. (1999) for 1993.

[c] Not surveyed in 1977, data for 1973 (Jehl 1977).

[d] From Danemann (1994) for 1989.

Table 4. Osprey nesting pairs in Scammon's Lagoon and vicinity 1946–1993 (from Castellanos and Ortega-Rubio 1995).

Year	No. pairs	Natural nests	Artificial structure
1946[a]	27	27	0
1971[b]	30	30	0
1977[c]	50	NA	(14)[d]
1980	71	58	13
1981	76	60	16
1982	86	62	24
1993	126	68	58

[a] Kenyon (1947), [b] Jehl (1977), [c] Henny and Anderson (1979), [d] At least 14 nests were on artificial structures.

1988 (Castellanos et al. 2002) and has a fairly long history of osprey studies by a number of scientists with the population now actively protected (V. Sanchez, pers. comm.) and steadily increasing from 27 nesting pairs in 1946 to 126 nesting pairs in 1993 (Table 4).

No nesting pairs were observed to the west along "Scavenger's Beach" between Scammon's Lagoon and Punta Eugenia in 1977, but an estimated 10 pairs were present in 1992. This appeared to be an "overflow" from the population increase in Scammon's Lagoon, and this apparent spread of nesting osprey has continued almost to Ensenada by 2002 (E. Palacios, pers. comm.). The islands north of Punta Eugenia (Natividad, Cedros and San Benitos) all contained nesting ospreys during both surveys, but fewer were found on Natividad in 1992, a similar number on Cedros in 1992, but more were found on San Benitos Islands in 1992. The total estimate for these islands declined slightly from an estimated 68 nesting pairs in 1977 to 60 in 1992.

Southwest Baja California, L.C.—This region extends south from Punta Eugenia along the Pacific Coast to Cabo San Lucas. In San Ignacio Lagoon, an estimated 27 pairs were nesting on two small islands (Ballenas) in 1977 (Table 3), but Reitherman and Storrer (1981) reported 129 occupied nests only 4 years later in 1981, therefore, either many ground nests were missed in 1977, or something was atypical that year in San Ignacio Lagoon. Gustavo Danemann (pers. comm.) mentioned fisherman's dogs on the islands in 1991, which could certainly disrupt ground nesting ospreys during any specific year, as well as storms and extremely high winds. The extremely high nest density on the islands in 1992 made it impractical to count occupied nests because birds flew and their association with a nest could not be determined with accuracy. Although our counting technique for a dense colony was inadequate, we counted ospreys at 85 nests, and no ospreys at 50 nests. Therefore, for this report we used the 1989 complete count of Danemann (1994) based upon many visits (143 occupied nests) to the two islands (Table 2). As with Scammon's Lagoon, San Ignacio Lagoon is also part of the large El Vizcaino Biosphere Reserve established after our 1977 surveys.

With the exception of San Ignacio Lagoon, only eight additional pairs were estimated nesting in this region in 1977. An estimated 55 pairs nested there in 1992, with most nesting south of Punta Santo Domingo (Table 3). A small concentration of osprey (8 pairs observed, estimated 14 pairs) were located in cacti between 25° 48′ N and 25° 54′ N, and another concentration was found in the Magdalena Bay/Almejas Bay region (19 pairs observed, estimated 32 pairs) and included nests on cliffs, cacti, and power poles. The most southern occupied nest on the Pacific side of Baja in 1992 was in a cactus at 23° 49′ N; 110° 43 W which was about 120 km south of Magdalena Bay.

Northeast Baja California, L.C.—An estimated 117 pairs of ospreys were nesting in this region along the Gulf from the mouth of the Colorado River south to Santa Rosalia in 1977, and a similar estimated 106 pairs in 1992 (Table 5). The terrain from the Colorado River south to Puertecitos was very flat and contained very few cacti suitable for nesting sites (such as the giant cardon, *Pachycereus pringlei*). The next series of occupied osprey nests in 1992 was in the San Luis Archipelago. The small number of osprey nests in 1992 (four observed pairs, estimated seven pairs) is in stark contrast to the 60–75 nesting pairs reported on the small archipelago by Bancroft (1927, 1932). He also stated that the archipelago was the location for the most northern nesting of the species in the region, as we observed also in 1992, except for one lone nest on an artificial structure on top of a building where a tripod structure was placed with a nesting platform (30° 45′ N; 114° 42′ W). The apparent reduction in the nesting population was most pronounced (37 pairs in 1977 to 24 pairs in 1992) in the northern portion of the region (Colorado River to Punta Remedios). In 1977, about half of the pairs were concentrated on a group of small islands (Miramar, Lobos, Encantada, San Luis, Pumice), but only seven pairs were estimated on these islands in 1992. The San Luis area has been subject to considerable human activity and disturbance, but recently (mid-1990s) has begun to receive patrolling and posting by Mexican wildlife officials (DWA, field notes).

Bahia de los Angeles and Bahia de las Animas located between Punta Remedios and Punta de las Animas contained an estimated 57 pairs in 1977 and an estimated 46 pairs in 1992. Declines were apparent on the small islands (Smith, la Ventana, Cabeza de Caballo, Mitlan, Islas de los Gemelos) in Bahia de los Angeles (35 to 29 pairs) and elsewhere (22 to 17 pairs). The southernmost portion of the region (Punta de las Animas to Santa Rosalia), which is a remote part of the coast, showed a population increase from 23 pairs in 1977 to an estimated 36 pairs in 1992. Cardon cacti became more important as a nesting substrate in the more southern portion of the region.

Southeast Baja California, L.C.—The coastal region south of Santa Rosalia to Cabo San Lucas contained an estimated 137 pairs in 1977 and a similar 130 pairs in 1992 (Table 5). The estimated number of occupied nests between Santa Rosalia and Loreto was also down from 1977 (66 to 50 pairs), and again is more subject to human activities (larger towns, etc.). Occupied nests in 1992 were again concentrated in and around Conception Bay, another rapidly developing tourist area (Carabias-Lillo et al. 2000, Ezcurra et al. 2002). The islands of Coronado, San Marcos and Santa Ynez again had nesting ospreys in 1992, but none were found on Ildefonso. On Santa Ynez, where five occupied nests were observed on the ground and one on a fishing shelter in 1977; only one occupied nest was observed on the ground and one on a tower in 1992. Tortuga Island was not surveyed in 1977, but only two occupied nests were observed there in 1992.

Between Loreto and Tambibiche an estimated 42 pairs were nesting in 1977, but an estimated 50 pairs in 1992. In 1977, an estimated 16 pairs nested along

Table 5. Distribution and abundance of occupied osprey nests at the *time of the aerial survey* on the Gulf side of Baja California and Midriff Islands in 1977 and 1992.

	1977	1992					
Location	Total estimate	Cliff	Cactus	Ground	Other	Max. observed	Total estimate
Northeast Baja, L.C.							
Colorado River to Punta Remedios	37.4	22.2	—	—	1.7	14	23.9
Punta Remedios to Punta de las Animas							
Los Angeles Bay Islands[a]	35.0	29.3	—	—	—	26	29.3
Other Locations	22.1	17.1	—	—	—	10	17.1
Punta de las Animas to Santa Rosalia	22.8	18.8	17.1	—	—	21	35.9
Subtotal	117.3	87.4	17.1	—	1.7	71	106.2
Southeast Baja, L.C.							
Santa Rosalia to Loreto	65.6	41.0	—	1.7	6.8	29	49.5
Loreto to Tambibiche	42.4	49.6	—	—	—	29	49.6
Tambibiche to Cabo San Lucas	29.3	30.8	—	—	—	18	30.8
Subtotal	137.3	121.4	—	1.7	6.8	76	129.9
Grand Total	254.6	208.8	17.1	1.7	8.5	147	236.1
Midriff Islands							
Guardian Angel	40.8	44.5	—	—	—	26	44.5
San Lorenzo, San Lorenzo Norte, Partida, Salispuedes, Raza	52.2	51.3	1.7	—	—	31	53.0
Tiburon[b]	71.8	46.2	118.0	—	—	96	164.2
San Estaban, Turner, Cholla[b]	22.8	46.2	—	—	—	27	46.2
Grand Total	187.6	188.2	119.7	—	—	180	307.9

Note: No adjustment of aerial survey population estimates was made here for nesting chronology.

[a] In 1993, the total estimate for Los Angeles Bay Islands was 25.2 occupied nests (max number observed 23).

[b] Survey conducted in 1993.

mainland cliffs or on immediately adjacent rocks, while in 1992 an estimated 17 pairs nested in the same locations. The slight increase took place on the islands with Carmen, Danzante, Monserrate, and Santa Catalina listed in order of importance.

The southernmost portion of the region (Tambibiche to Cabo San Lucas) contained an estimated 29 pairs in 1977 with about half the nests along the shoreline and the rest on islands with Cerralvo and Espiritu Santo most important. In 1992, the estimated 31 pairs included 12 along the shoreline and 19 on islands. Islands with occupied nests included Cerralvo, Santa Cruz (and a small island immediately to the south), San Jose and Espiritu Santo. None of these islands had more than three nests observed (estimated five nests) in 1992. The most southern nesting pair was found on a tower at the southern end of Isla Cerralvo (24° 09′ N; 109° 52′ W).

Midriff Islands.—An estimated 188 pairs of ospreys nested on the islands in this region located at about latitude 29° N Latitude in the Gulf of California in 1977; however, an estimated 308 pairs were present in 1992 or 1993 (islands nearer Sonora surveyed in 1993) (Table 5). The estimated numbers nesting on Guardian Angel (41 pairs in 1977 vs. 45 pairs in 1992) and the chain of islands to the south (Partida, Raza, Salsipuedes, San Lorenzo Norte and, San Lorenzo) (52 pairs in 1977 vs. 53 pairs in 1992) were basically identical during both survey years. In contrast, on the eastern side of the Gulf of California, the large island of Tiburon contained an estimated 72 pairs in 1977, but more than doubled to 164 pairs in 1993, while the population on the nearby San Esteban, Turner and Cholla doubled from an estimated 23 pairs to 46 pairs in 1993. The population increase on Tiburon was equally apparent for nests on cliffs (estimated 20 to 46 pairs) and nests in cardon cacti (52 to 118 pairs). Van Rossem (1932) noted ospreys nesting at frequent intervals along the Tiburon coast, but provided no quantitative information. Tershy and Breese (1997) report the osprey as a rare visitor on San Pedro Martir, probably because of the lack of shallow water; the island was not surveyed in 1977 or in 1992–1993.

Coastal Sonora.—An estimated 124 pairs of ospreys were nesting in coastal Sonora in 1977, but the number increased to an estimated 214 pairs in 1993 (Table 6). The extreme northern coastal area is flat with no cacti, then cardon began appearing sporadically. Further south along the coast, there are a few sandy cliffs and, eventually, some rocky cliffs. Some pairs were nesting in the cliffs, but most pairs were in cardon cacti. The first nest we located in 1993 was south and east of Puerto Penasco at 31° 12′ N; 113 04′W and found on a metal power pole about 1.5 km inland. Mellink and Palacios (1993) reported an osprey nest in the same general area in 1982, and reported several nests along the railroad between Lopez Collada and Sahuaro in 1991 and 1992 (unsure how many occupied). The nests were on power line towers or telephone poles, suggesting that artificial structures promoted ospreys colonizing the area where no natural nest sites were available (land flat and no suitable cacti). The power line towers were constructed in 1978 and 1979 (Mellink and Palacios 1993). Then, a series of 11 nests were observed (estimated 19 nests) in cardon cacti between 30° 55′ N and 30° 23′ N. These were followed by a series of eight nests observed (estimated 14 nests in cliffs between latitude 30° 17′ N and 30° 07′ N). From 30° N to Punta Sargento, an estimated 72 pairs were nesting and nearly all were in cacti. From Punta

Table 6. Distribution and abundance of occupied osprey nests at the *time of aerial survey* in coastal Sonora and Sinaloa in 1977 and 1993.

Location	1977	1993					
	Total estimate	Cliff	Cactus	Mangrove	Other	Max. observed	Total estimate
Coastal Sonora							
Colorado River to Punta Sargento[a]	78.4	17.1	87.2	—	1.7	62	106.0
Punta Sargento to Sinaloa border	45.6	15.4	87.2	—	5.1	76	107.7
Subtotal	124.0	32.5	174.4	—	6.8	138	213.7
Coastal Sinaloa							
Sonora border to Topolobampo	6.5	—	10.3	1.7	1.7	8	13.7
Topolobampo to Punta Baradito[b]	61.9	—	152.2	13.7	—	97	165.9
Punta Baradito to Mazatlan	1.6	—	—	—	—	—	0
Subtotal	70.0	—	162.5	15.4	1.7	105	179.6
Grand Total	194.0	32.5	336.9	15.4	8.5	243	393.3

Note: No adjustment of aerial survey population estimates was made here for nesting chronology.

[a] Includes Hamerstrom ground counts (36 pairs) behind Punta Sargento in 1977 (see Henny and Anderson 1979).

[b] Mainly on outer barrier islands: San Ignacio, Macapule and Altamura.

Sargento south to the Sinaloa border, the population more than doubled from an estimated 46 pairs in 1977 to 108 pairs in 1993. The nests south of Punta Sargento in 1993 included a concentration in the Kino Estero, but also a fairly even distribution south to Guaymas. A portion of the Sonora population (El Desemboque to the town of Kino) was studied by Cartron (2000) from 1992 to 1997. He reported a population increase in his study area from 1992 to 1996 (25 to 34 pairs observed, but thought several nests were missed the first year) and then a decline in 1997 to 29 pairs when production was extremely poor. Only one nest was south of Guaymas where the dominant species of cactus in our survey area changed from saguaro (*Cereus giganteus*) that would support a nest to organpipe (*Cereus thurberi*) that would not. The lone nest was on a tower (26° 18′ N; 109° 15 W).

Coastal Sinaloa.—This region extends from the Sonora border south to Mazatlan. An estimated 70 pairs of ospreys nested along coastal Sinaloa in 1977 and 180 pairs in 1993 (Table 6). From the Sonora border to Topolobampo, an estimated seven pairs nested in 1977, but increased to an estimated 14 pairs in 1993. All of these pairs were nesting on Santa Maria, which is a barrier island south and west of Los Mochis. Most nests were in cacti, although a derelict boat and mangrove tree were also used. South of Topolobampo to Punta Baradito an estimated 62 pairs were nesting in 1977, but the numbers increased to an estimated 166 pairs in 1993. This area was further sub-divided into two areas with the split at 25° 10′ N. From Topolobampo to 25°10′ N, which included the barrier islands of San Ignacio and Macapule, had an estimated 31 pairs nesting in 1977 and an estimated 118 pairs in 1993. South of 25° 10′ N, which included Santa Maria Bay and the barrier island of Altamura, we estimated 31 pairs in 1977, but an estimated 48 pairs in 1993. Carmona and Danemann (1994) studied Santa Maria Bay in 1988, and reported about 40 pairs of nesting osprey which generally supports our observations. Most ospreys at the above two areas were nesting on barrier islands and peninsulas associated with several large bays. Mangroves and other brushy trees were abundant and some of the ospreys nested in them. The species of cacti changed again to a type that branches about 1.5 m above ground (*Pachycereus pecten-aboriginum*), and most nested again in the cactus. The most southern nesting osprey was at 24° 54′ N; 108° 07′ W. During the 1977 survey the most southern occupied nest was south of Punta Barradito at 24° 38′ N, but cacti in this area are sparse and of the wrong shape and the tops of trees will not support a nest. No occupied osprey nests were found south of Punta Baradito in 1993. The terminus of the survey was Mazatlan both years of the survey, and it is possible that a few more scattered nests could be found farther south. However, CJH flew further south along the coast at low altitude to the Guatamala border on another project in January 1983 (Henny and Blus 1986) and saw no osprey nests.

Nesting Sites

Dead trees or trees with dead tops are the "typical" sites for nesting ospreys in the western United States (Henny et al. 1978a, b), but ospreys in more recent years have nested on power poles and transmission towers in response to the shortage of tree sites (Henny and Kaiser 1996). Trees, with the exception of mangroves at more southern latitudes of this study area, were rare. Consequently, the ospreys used different nest sites (Table 7). The proportions of nests found in

Table 7. Types of nest sites selected by ospreys in the study area, 1997 and 1992–1993.

	Estimated number of occupied nests (%)	
Nest site substrate	1977	1992–1993
Cliff	479 (59.1%)	542 (39.8%)
Cacti	213 (26.3%)	506 (37.2%)
Ground	59 (7.3%)	213 (15.6%)
Human-made Structures	35 (4.3%)	85 (6.2%)
Mangrove or Other Trees	24 (3.0%)	16 (1.2%)
Total	810 (100%)	1,362 (100%)

Note: No adjustment of aerial survey population estimates was made here for nesting chronology.

the five categories of nesting substrate (Table 7) varied significantly ($P < 0.01$, Kolmogorou-Smirnov Test) from 1977 to 1992–1993, mainly due to the increase of nests found in cacti and on the ground. Remote, inaccessible cliffs and cacti were still the most important substrates used for nesting during both surveys, as nesting above ground level is critical for ospreys on the mainland where predators are common. Coyotes (*Canis latrans*) were observed throughout the study area, and it was not uncommon to see several each day during our aerial surveys. Both Kenyon (1947) and Jehl (1977) monitored coyote depredation of ground nests, even when nests were located on small islands and Danemann (1994) mentioned fisherman's dogs as well as coyotes as a problem on small islands in San Ignacio Lagoon.

Ground-nesting ospreys were restricted to very small islands at three locations: Scammon's Lagoon, San Ignacio Lagoon and Santa Ynez Island, and were likely much more abundant in the past (e.g., Jehl 1977) and recovering in importance, given recent protection. In the Bahia de los Angeles area, DWA knew of 2–3 ground nests in the mid-1970s, but annual observations since then have yielded no ground nests. Overall, ground nests on islands increased from 1977 to 1992, primarily because of the large population increase at San Ignacio Lagoon. San Ignacio Lagoon is part of the Biosphere Reserve System in Baja California (Anderson et al. 2002) and subject to management and protection since the early 1990s. The use of human-made structures as nest sites also increased (from 35 pairs to 85 pairs) as a result of increased human activity at several locations, including the building of some nesting structures specifically for ospreys at Scammon's Lagoon.

Discussion and Conclusions

Much of our discussion relates to larger regions with 95% C.I. provided (see Table 8), although point estimates are provided for smaller areas. The maximum number of nests observed from each area is shown in Tables as well as the estimated size of that population which provides additional insight into data quality. Comparisons with published results from several areas (e.g., Santa Maria Bay) (Carmona and Danemann 1994) also show good agreement with our estimated values. Furthermore, we do not believe that change in population size between the two survey periods (1977 and 1992–1993) was a function of changes in Visibility Rates, in fact, the Visibility Rates for cliffs and cactus combined were nearly identical for the two surveys, which supports the repeatability of the survey

Table 8. A summary of changes in estimated number of occupied osprey nests in the study area, 1977 and 1992–1993.

Location	1977[a]	1992–1993[a]	Change
NW Baja, L.C.	138.0 (164.2)	226.9 ± 20.6[b] (246.1)[c]	+64% (+50%)
SW Baja, L.C.	35.4 (42.1)	197.7 ± 11.1[b] (208.1)[c]	+458% (+394%)
NE Baja, L.C.	117.3 (139.6)	106.2 ± 21.6 (126.4)	−9% (−9%)
SE Baja, L.C.	137.3 (163.4)	129.9 ± 26.5 (154.6)	−5% (−5%)
Midriff Is.	187.6 (223.2)	307.9 ± 62.8 (366.4)	+64% (+64%)
Sonora	124.0 (140.7)[c]	213.7 ± 43.6 (254.3)	+72% (+81%)
Sinaloa	70.0 (83.3)	179.6 ± 36.6 (213.7)	+157% (+157%)
Totals	810 (957)	1,362 ± 278 (1,570)	+68% (+64%)

[a] First estimate refers to those nesting at the *time of the aerial survey* including those missed by aerial survey; estimate in ( ) refers to double-adjusted population estimate which includes those that were not nesting at the time of the survey due to asynchronized nesting season at more than southern latitudes (initial estimate × 1.19, see Table 2).

[b] N ± 95% C.I. for regional population estimates (C.I., assumes variance 0 for total counts at Scammon's and San Ignacio Lagoons).

[c] Complete counts were used for Scammon's Lagoon, San Ignacio Lagoon, and behind Punta Sargento, thus that portion was not adjusted for asynchronized nesting season.

method for nesting ospreys (Table 1). We found that the general distribution of ospreys in our survey area had not changed appreciably between 1977 and 1992–1993, although changes in abundance were apparent and variable.

The region of Northwest Baja has the best documented changes in osprey population numbers over time in Mexico. Prior to our 1977 survey (Henny and Anderson 1979), most of the quantitative studies of osprey in Mexico were restricted to portions of Northwest Baja, and Jehl (1977) reviewed these studies. The four most northern islands or groups of islands (Los Coronados, Todos Santos, San Martin and San Geronimo) are of interest, because the last pair nested there in 1971. Los Coronados historically had no nesting records, but ospreys were common on the other three islands. However, by the 1920s ospreys were gone from Todos Santos and San Geronimo, and reduced to only one pair by 1969–1971 on San Martin. San Martin had about 30 pairs nesting on the ground in 1913. None of these more northern islands had nesting ospreys during our surveys in 1977 and 1992. These extirpations were concomittant with extirpations on islands off southern California (Kiff 1980).

As we mentioned in our earlier report, the road system heading south from Tijuana (where nesting ospreys are no longer present) was along the coast, but further south the main road was inland away from the coastline. Osprey pairs were only found nesting along the coast after the road veered inland away from the coast. Inland nests near the main highway are rare, but include the famous and well-known osprey nest on the sign near Guerrero Negro and another near Villa Jesus Maria. Both are right over or very near the main road and about 7–9 km from water. We know of no other nests this distance from water.

Most of the osprey increase in Northwest Baja occurred in Scammon's Lagoon and the adjacent areas to the north and west. Scammon's Lagoon was originally developed in 1953 for salt production, and now has one of the worlds largest salt-production companies (Castellanos et al. 1999). In earlier years, the nesting pairs were on the ground on three small islands in the lagoon, but more recently, utility poles (some modified with platforms above the electric wires) in the town of Guerrero Negro, plus towers, nesting platforms built for ospreys, pilings, and channel markers (associated with development of salt industry) have become important (Castellanos and Ortega-Rubio 1995) just as elsewhere (Henny and Kaiser 1996). Nesting platforms were first constructed in the Scammon's Lagoon area in 1982 and were used immediately (Castellanos and Ortega-Rubio 1995). The presence of wildlife officials actively involved with ospreys in Guerrero Negro in 1992 was a noticeable change from 1977. Furthermore, osprey nests on power poles in the city of Guerrero Negro were common and protected, and none were present during the 1977 survey. Permanent and successful use of utility poles by ospreys began in 1984 as a result of three factors: law enforcement, environmental education programs, and utility pole modification (extension platforms) (Castellanos et al. 1999). West of Scammons Lagoon in 1977 we reported that populations on Natividad, Cedros and San Benitos, which are generally more distant from human populations, appeared to be stable. The overall osprey population on the three islands in 1992 was down slightly; the decline was more pronounced at Natividad, which is the closest to the mainland and had the most human activity, e.g., many roads were evident on the island in 1992.

We provide an additional estimate of the size of populations (using a double-adjustment including nesting asynchrony) which may be considered preliminary, and is only mentioned from here onward. The percentage change in population estimates was not influenced by the nesting asynchrony adjustment, because the same adjustment was used for all data. However, the size of the population was increased except in areas where detailed nesting studies were conducted. The estimated population in Northwest Baja increased 50% from 1977 to 1992 (Table 8). The osprey population in Southwest Baja also increased dramatically from 1977 (42 pairs) to 1992 (208 pairs) (Table 8), with most of the change the result of the tremendous increase in San Ignacio Lagoon. Historically, Huey (1927) did not report ospreys nesting on Ballenas Islands in San Ignacio Lagoon in 1927 (visited islands on 12 April), although the date of visit was well within the nesting cycle (Table 2). Huey did report seeing ospreys. However, Bancroft (1927) reported them abundant at both San Ignacio and Scammon's Lagoons (uncertain of year). There is some indication that a portion of the increase from 1977 to 1992 in the lagoons may not be real because of the much larger nesting osprey population (129 pairs) counted in the lagoon only four years after our initial survey (Reitherman and Storrer 1981). Storms (winds), dogs on the islands or other factors may have resulted in lower counts at the time of our survey in 1977 or we may have just missed some ground nests. Now the osprey nesting on the two small islands in San Ignacio Lagoon, which were well studied by Reitherman and Storrer (1981) and Danemann (1994), may have the highest density in the world! At both Scammon's Lagoon and San Ignacio Lagoon, the ospreys probably also benefitted from the additional presence of wildlife officials involved with the gray whales (*Rhachianectes gibbosus*) that calve in both lagoons and an island-protection program run by the Guerrero Negro group. Another nesting concentration in the region was found in the Magdalena Bay/Almejas Bay region where the only nesting bald eagles (*Haliaeetus leucocephalus*) in Baja California are now located (Henny et al. 1993). We are aware that in the late 1970s and 1980s, about 25–30 osprey pairs were shot and nests removed from structures near the town of

San Carlos (Magdalena Bay) (J.E. Mendoza, pers. comm.), and it might be that the increased population around Magdalena Bay represents a local population recovery.

In contrast to the osprey population increase on the Pacific side of Baja California, the osprey population on the Gulf of California side appeared unchanged or in a slow, but general decline in both the northern (−9%) and southern regions (−5%) (Table 8). No lagoons with small islands are found along the Gulf side, and lagoons were the primary focus for population increases on the Pacific side. The Pacific side of Baja California, which had fewer nesting pairs than the Gulf side in 1977 (206 vs. 303), had more nesting pairs in 1992 (454 vs. 281) (Table 8).

The Midriff Islands showed an interesting dichotomy, i.e., the islands near the Gulf coast of Baja (Guardian Angel and the series of islands associated with San Lorenzo) maintained nearly identical numbers between 1977 and 1992 (93 pairs vs. 98 pairs) (Table 5), while those closer to Sonora (Tiburon, San Estaban, Turner and Cholla) all showed major increases (95 pairs vs. 210 pairs). All islands in the Gulf of California are part of a Biosphere Reserve, called "Islands of the Sea of Cortez," for the protection of animals and plants (Alvarez-Castañeda 1997). Patrol of the islands by reserve personnel of the wildlife service only began near the end of 1997, so the islands have a long history of use without formal supervision, with most supervision restricted to the islands with the most tourist activity (Alvarez-Castañeda and Oretega-Rubio 2003). Other Midriff Islands are fortunately part of a developing management plan (Carabias-Lillo et al. 2000, Ezcurra et al. 2001, Anderson et al. 2002) and will receive more protection in the future.

The estimated nesting osprey population along mainland Mexico (Sonora and Sinaloa to Mazatlan) more than doubled (224 pairs to 468 pairs) between 1977 and 1993 (Table 8). The increase was more pronounced in Sinaloa than in Sonora. The largest increase occurred in Sinaloa on the outer barrier islands of San Ignacio, Macapule and Altamura. The increase was the greatest on San Ignacio Island (different from San Ignacio Lagoon discussed earlier). Most nests were located in cacti and apparently near abundant fish populations in adjacent bays and estuaries. Carmona and Danemann (1994) mentioned the possibility of agricultural pesticides flowing into the bays and estuaries from streams that drain farmlands. The increase in osprey populations in coastal Sinaloa from 1977 to 1993 may be the result of reduced use or termination of the use of persistent pesticides, but no pesticide residue data from osprey eggs were ever collected in coastal Sinaloa. If DDT/DDE was involved in an earlier osprey population decline in Sinaloa, that we would now be seeing a recovery from, reduced productivity would have occurred (Wiemeyer et al. 1988). Unfortunately, in addition to the lack of pesticide studies, there were no osprey production studies from this region to evaluate the possible influence of pesticides in earlier years. Our explanation for the observed increase is therefore problematic.

Nest sites used by the ospreys in Mexico include some structures made by humans, and although the percentage is increasing, it remains small (6%, Table 7) except in Scammon's Lagoon (46%, Table 3). It is anticipated that ospreys will continue to adjust to these structures, and they will become more important in Mexico over time just like they have in other parts of the world. At many locations in the United States and elsewhere, the percentage of nests on human-made structures is extremely high, e.g., 85% along Willamette River in western Oregon

(Henny and Kaiser 1996). As the ospreys begin nesting on power poles or transmission towers, the utility companies will need to address the issue of power outages caused by nests as well as osprey electrocutions. Modifications of nests on power poles with pole top extension platforms are already occurring at some locations. The science of managing osprey nests on power poles is rapidly developing at the present time in the United States and elsewhere (APLIC 1996).

In summary, the osprey population (double adjusted) increased from an estimated 957 pairs in 1977 to an estimated 1,570 pairs in 1992–1993 (Table 8) and major increases seemed to be focused in areas where wildlife personnel had a presence (in some cases not specifically assigned to ospreys), although a general population increase occurred at all regions except the Gulf coast of Baja California. This atypical pattern of population change along the Gulf coast of Baja California should be used to focus additional investigations in that region. A management plan and proposed Bahia de los Angeles National Park (G. Danemann, pers. comm.) in the near future should be helpful. A check of occupied vs. unoccupied nests in a 1992 sample observed from the air on both coasts of Baja California showed nearly equal numbers, but near La Paz on Espiritu Santo and Cerralvo the ratio was skewed heavily toward unoccupied nests (1 vs. 16 and 3 vs. 11, respectively). Is this the result of an earlier nesting season at 24° N. Latitude, or was there possibly a disturbance issue related to human activity from LaPaz? Anderson et al. (1976) brought up the issue of increased human activity in the Gulf of California and its potential effect on vulnerable seabirds. Interest in this subject has increased in recent years (e.g., Tershy et al. 1999, Lopez-Espinosa 2002). We are convinced that human activity has increased tremendously from 1977 to 1992, especially along the Gulf side of Baja California. This increase has taken place in the form of more tour boats, kayaks, and increased construction, although we do not have quantitative data. Ospreys are generally a tolerant species of humans and their activities and habituate to them. However, there are critical times in the nesting cycle (which is much longer in Mexico than farther north due to the lack of nesting synchrony) when presence of humans can prevent eggs from being incubated, the very young from being shaded by the parents from the hot sun, or young becoming more vulnerable to predators such as common ravens (*Corvus corax*), yellow-footed gulls (*Larus livens*), and other species. When official wildlife management presence has occurred, sometimes not even related to ospreys, we have observed ospreys prosper.

This survey data is now more than 10 years old, and there is no guarantee that the osprey populations of the various regions continued to increase or even remain stable after 1992–1993. It is anticipated that another survey will be conducted in the near future.

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Literature Cited

Alvarez-Castañeda, S.T. 1997. Diversidad y conservacion de pequeños mammiferos terrestre de B.C.S. Ph.D. Thesis, Universidad Nacional Autonoma de Mexico, La Paz, Mexico.

——— and A. Ortega-Rubio. 2003. Current status of rodents on islands in the Gulf of California. Biol. Conser. 109:157–163.

Anderson, D.W., J.E. Mendoza, and J.O. Keith. 1976. Seabirds in the Gulf of California: A vulnerable international resource. Nat. Resour. *J.* 16:483–505.

———, E. Palacios, E. Mellink, and C. Valdés-Casillas. 2002. Migratory bird conservation and ecological health in the Colorado River Delta Region, pp. 1091–1109. *In*: D.J. Rapport, W.L. Lasley, D.E. Rolston, N.O. Neilson, C.O. Qualset, and A.B. Damania [Eds.]. Managing for Healthy Ecosystems. Lewis Publishers, New York U.S.A.

Avian Power Line Interaction Committee (APLIC). 1996. Suggested practices for raptor protection on power lines: The state of the art in 1996. Edison Electric Institute/Raptor Research Foundation, Washington, DC U.S.A.

Bancroft, G. 1927. Notes on the breeding coastal and insular birds of central Lower California. Condor 29:188–195.

———. 1932. Lower California: A cruise–The flight of the Least Petrel. G.P Putnam's Sons, New York U.S.A.

Carabias-Lillo, J.J. Maza-Elviva, D. Guttiérrez-Carbonell, M. Gómez-Cruz, G. Anaya-Reyna, A. Zavala-González, A.L. Figueroa, and B. Bermúdez-Almada. 2000. Programa de manejo área de protección de flora y fauna Islas del Golfo de California. Comisión Naciona de Áreas Naturales Protegidas, Tlacopac, Mexico DF.

Carmona, R. and G.D. Danemann. 1994. Nesting waterbirds of Santa Maria Bay, Sinaloa, Mexico, April 1988. Western Birds 25:158–162.

Cartron, J-L. E. 2000. Status and productivity of Ospreys along the eastern coast of the Gulf of California: 1992–1997. J. Field Ornith. 71:298–309.

Castellanos, A. and A. Ortega-Rubio. 1995. Artificial nesting sites and Ospreys at Ojo de Liebre and Guerrero Negro Lagoons, Baja California Sur, Mexico. J. Field Ornith. 66:117–127.

———, ——— and C. Arguelles-Mendez. 1999. Osprey population response to availability of artificial nesting sites at Lagunas Oje de Liebre and Guerrero Negro, Baja California Peninsula, pp. 165–175. *In*: Ferrer, M. and F.G. Janss [Eds.] Birds and power lines, Quercus Publishing, Madrid, Spain.

———, L. Arriaga and C. Lopez. 2002. El Vizcaino Biosphere Reserve: A case study of conservation and development in Mexico. Natural Areas J. 22:331–339.

Danemann, G.D. 1994. Biologia reproductiva del Aguila Pescadora (*Pandion haliaetus*) en isla Ballena, Laguna San Ignacio, Baja California Sur, Mexico. Instituto Politecnico Nacional, Departamento de Biolgia Marina, CICIMAR LaPaz, Baja California Sur Mexico.

Ezcurra, E., L. Bourillón, A. Cautú, M.E. Martínez, and A. Robles. 2002. Ecological conservation. *In*: T.J. Case, M.L. Cody, and E. Ezcurra (Eds.) A new island biogeography of the Sea of Cortés. Oxford Univ. Press, New York U.S.A.

Grinnell, J. 1928. A distributional summation of the ornithology of Lower California. Univ. Calif. Publ. Zool. 32.

Henny, C.J. and D.W. Anderson, 1979. Osprey distribution, abundance, and status in western North America: III. The Baja California and Gulf of California population. Bull. So. Calif. Acad. Sci. 78:89–106.

——— and L.J. Blus. 1986. Radiotelemetry locates wintering grounds of DDE-contaminated Black-crowned Night-Herons. Wildl. Soc. Bull. 14:236–241.

——— and J.L. Kaiser. 1996. Osprey population increase along the Willamette River, Oregon, and the role of utility structures, 1976–1993, pp. 97–108. *In*: Bird, D.M., D.E. Varland, and J.J. Negro [Eds.] Raptors in Human Landscapes, Academic Press, Ltd., London U.K.

——— and A.P. Noltemeier. 1975. Osprey nesting populations in the coastal Carolinas. Am. Birds 29:1073–1079.

———, J.A. Collins, and W.J. Deibert. 1978a. Osprey distribution, abundance, and status in western North America: II. The Oregon population. Murrelet 59:14–25.

———, B. Conant, and D.W. Anderson. 1993. Recent distribution and status of nesting bald eagles in Baja California, Mexico. J. Raptor Research 27:203–209.

———, M.M. Smith, and V.D. Stotts. 1974. The 1973 distribution and abundance of breeding Ospreys in the Chesapeake Bay. Chesapeake Sci. 15:125–133.

———, D.J. Dunaway, R.D. Mallette, and J.R. Koplin. 1978b. Osprey distribution, abundance, and status in western North America: I. The northern California population. Northwest Sci. 52:261–272.

Huey, L.M. 1927. The bird life of San Ignacio and Pond Lagoon of the western part of Lower California. Condor 29:239–243.

Jehl, J.R., Jr. 1977. History and president (sic) status of Ospreys in northwestern Baja California. Pp. 241–245 *In:* Ogden, J.C. [Ed.] Trans. N. Am. Osprey Res. Conf., U.S. Natl. Park Serv., Washington, DC U.S.A.

Kenyon, K.W. 1947. Breeding populations of the Osprey in Lower California. Condor 49:152–158.

Kiff, L.F. 1980. Historical changes in resident populations of California Islands raptors, pp. 651–673. *In:* Power, D.M. [Ed.] The California Islands: Proceedings of a Multi-disciplinary Symposium, Santa Barbara Mus. Nat. History, Santa Barbara, CA U.S.A.

Lopez-Espinosa, R. 2002. Evaluating ecotourism in natural protected areas of LaPaz Bay, Baja California Sur, Mexico: Ecotourism or nature-based tourism? Biodiversity and Conser. 11:1539–1550.

Mellink, E. and E. Palacios. 1993. Notes on breeding coastal waterbirds in northwestern Sonora. Western Birds 24:29–37.

Reitherman, B., and J. Storrer. 1981. A preliminary report on the reproductive biology and ecology of the Whale Island Osprey (*Pandion haliaetus*) population, San Ignacio Lagoon, Baja California Sur, Mexico. Western Foundation of Vertebrate Zoology. Los Angeles, CA U.S.A.

Tershy, B.R. and D. Breese. 1997. The birds of San Pedro Martir Island, Gulf of California, Mexico. Western Birds 28:96–107.

———, L. Bourillon, L. Metzler and J. Barnes. 1999. A survey of ecotourism on islands in northwestern Mexico. Environ. Conser. 26:212–217.

van Rossem, A.J. 1932. The avifauna of Tiburon Island, Sonora, Mexico, with description of four new races. Trans. San Diego Soc. Nat. History 7:119–150.

Wiemeyer, S.N., C.M. Bunck and A.J. Krynitsky. 1988. Organochlorine pesticides, polychlorinated biphenyls, and mercury in Osprey eggs—1970–1979—and their relationships to shell thinning and productivity. Arch. Environ. Contam. Toxicol. 17:767–787.

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Caudal Spine Replacement and Histogenesis in the Round Stingray, *Urobatis halleri*

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Abstract.—Many stingray species replace their poisonous caudal spines seasonally; however, it is hypothesized that spine replacement may also be induced through a traumatic injury to the caudal spine. To determine whether the round stingray, *Urobatis halleri,* can replace damaged spines outside of normal spine shedding season, secondary spine growth of stingrays with clipped, removed, and intact primary spines was compared. Additional rays were separately collected for histological analysis of spine development. Though initial results indicated no difference in spine initiation among the treatments, later spine removals showed the ability of *U. halleri* to replace lost spines.

The round stingray, *Urobatis halleri,* is a demersal elasmobranch that resides in sandy or muddy bays and shorelines to a depth of 21 m, ranging from Eureka, California to Panama (Knopf 2000). The round stingray possesses a venomous caudal spine close to the base of the tail. The elongated tapering spine consists of a thin outer layer of enamel-like material, an inner core of vasodentine, and retrorse serrations along the lateral margins. The venom-secreting cells are thought to reside in the ventro-lateral-glandular grooves, located laterally to the mid-ventral ridge of the spine. The entire spine is covered with an integumentary sheath. The spine is attached to the dorsal surface of the tail by a dense network of collagenous dermis (Halstead et al. 1955), and is thought to be a modified placoid scale (Reif 1982; Kemp 1999).

Urobatis halleri, like other stingrays, utilize their spines in defense against predators and occasionally on humans, who inadvertently step on them (e.g., Gudger 1932, 1946; Campbell 1951; Russell 1953). The spine is a major cause of stingray-related injuries to beachgoers, surfers, scuba divers, and fishers. On average, approximately 500 stingray-related injuries are reported by beachgoers during summer months along southern California beaches and it is thought that the round stingray is responsible for a majority of these injuries (Russel 1953; R. Pounds, Pers. Comm.).

Because stingray-related injuries are frequent, and can in rare cases be life threatening, an understanding of caudal spine function and replacement in stingrays is important. Several studies, examining spine replacement in other stingray species have found that many of these species replace their spines seasonally. Teaf et al. (1987), who worked with a marine population of *Dasyatis sabina,* and Amesbury et al. (1997), who worked with a freshwater population of *D. sabina,* found that shorter secondary (replacement) spines appeared posterior to the primary (original) longer spines in late spring and early summer. Rays exhibited two spines until early fall, when the initial primary spines were shed, leaving the secondary spines as the new primary spines. In addition, three years of field data indicate that *U. halleri* generate a replacement spine posterior to the primary spine every summer. The primary spine is shed in the fall when the secondary replacement spine reaches approximately the same length as the primary spine (Lowe et al. unpub. data).

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Beyond the normal seasonal spine renewal cycle, it is not known whether injury to or removal of the primary spine could induce rapid spine replacement. Intact stingray spines have been found in the jaws of large sharks and seals, indicating that rays may occasionally lose entire spines during attempted predation events (e.g., Gudger 1932, 1946; Campbell 1951; Russell 1953). Removed or damaged placoid scales of nurse (*Ginglymostoma cirratum*) and leopard (*Triakis semifasciata*) sharks have been shown to be rapidly replaced (Reif 1978), possibly because of their vital function in protecting the fish against the external environment (Quilhac et al. 1999). Therefore, if caudal spine development of stingrays is similar to that of typical placoid scale regeneration, then rapid replacement of removed spines in *U. halleri* should be possible, and the ability of stingrays to rapidly replace lost or damaged spines could decrease their risk of predation.

While little is known about the histogenesis of stingray spines, there has been considerable study of the regeneration process of elasmobranch placoid scales. Placoid scales develop in the upper layer of the dermis as dermal papillae (scale primordia), which eventually differentiate into an innermost dental papilla, a layer of odontoblasts that secrete dentine, and a layer of ameloblasts that secrete enamel (Kemp 1999). Due to the homology in structure and composition of placoid scales, stingray caudal spines probably develop in a similar manner. Amesbury et al. (1997), the only other study to describe some spine development, found that a primordial spine bud precedes the appearance of the secondary spine in *Dasyatis sabina*. The primordial spine bud was defined as a pinkish area of differentiated tissue located ventral and posterior to the origin of the primary spine.

Thorson et al. (1988) hypothesized that stingrays might possess the ability to replace lost or damaged spines, but presented no evidence to support this hypothesis. The goal of our study was to determine whether *U. halleri,* whose primary spines have been removed, would begin to replace the removed spine outside the normal spine replacement period and to histologically describe the development of the newly forming replacement spine.

Materials and Methods

Animal Collection and Sample Size

Seventeen adult *Urobatis halleri* were collected with beach seines in Seal Beach, Los Angeles County, California in December 2001, and February, April, and July 2002. Twelve males and three females, ranging in size from 157–184 mm disk width, were randomly selected and assigned to one of three experimental groups: removed, clipped, or intact primary caudal spines (Table 1). The rays were kept in the California State University Long Beach (CSULB) Shark Lab until the end of October 2002, after which all rays were released back in to the

Table 1. Summary information for *Urobatis halleri*. The treatments are designated as r = removed primary spines, cl = clipped primary spines, i = intact. Secondary treatments are designated as 2r = secondary spine removals.

Ray #	Caught	Sex	Weight (g)	Disk width (mm)	Treatment	2nd treatment
1	Feb-02	m	247	169	r	2r
2	Feb-02	f	250	163	r	—
3	Feb-02	m	308	170	r	2r
4	Dec-01	f	298	170	r	—
5	Feb-02	m	325	175	r	—
6	Apr-02	m	318	176	cl	—
7	Apr-02	m	320	174	cl	2r
8	Apr-02	m	369	184	cl	—
9	Apr-02	m	307	175	cl	2r
10	Apr-02	f	252	157	cl	—
11	Apr-02	m	252	160	i	—
12	Apr-02	m	298	166	i	2r
13	Apr-02	m	291	168	i	—
14	Apr-02	m	306	168	i	2r
15	Jul-02	m	299	176	i	2r
16	Jul-02	f	357	178	—	2r
17	Oct-02	m	302	169	—	2r

wild, with the exception of seven rays that were retained for an additional five months, along with rays collected in July and October 2002.

Animal Maintenance

Urobatis halleri were maintained in two separate closed-system-seawater tanks (2,250 and 3,400 l tank). Seawater quality (pH, ammonia, nitrite, and nitrate) was monitored weekly, while salinity and temperature was monitored every other day. Light was kept on a 12 L:12 D cycle over the course of the study. Rays were fed *ad libitum* once every other day, on a diet of anchovy, shrimp, and bay mussels.

Experimental Treatments

Five *U. halleri* were randomly assigned to each of three treatment groups. Rays in one treatment group had their primary spine clipped within 2 mm of the base of the spine. Rays in the second treatment group had their entire primary caudal spine surgically removed from its attachment area with a scalpel, while the third treatment group, serving as a control, had their primary spine left intact. All rays were anaesthetized using MS222 at a concentration of 125 mg MS222/l seawater. Anaesthetized rays required approximately 6 min for full anesthesia and 8 min to fully recover in fresh saltwater. The spine removals were performed in mid April 2002 and spine clippings in late April 2002. Each ray was uniquely identified by a small series of fin clips.

Nine rays had their spines removed again in November 2002, after the normal spine shedding season (Sept.–Oct.). These rays were monitored monthly for up to four months for signs of newly developing replacement spines.

Spine Length Measurements

The presence or absence of a replacement spine was monitored visually and by probing the area of spine attachment. Measurements of replacement spines were made from the distal spine tip to the eruption site of the developing spine using calipers. Due to some initial difficulties with measurement accuracy, measurements of replacement spines of rays in the removed spine treatment were remeasured using image analysis (Scion) from digital pictures taken during each set of measurements. Replacement spine length (mm), disk width (mm), and body mass (g) were measured weekly or biweekly.

Data Analysis

Replacement spine length data were transformed using a logit-transformation and compared using an Analysis of Covariance (ANCOVA) to determine if there was a significant increase of spine length over time, if initiation of replacement spine growth began significantly earlier in any one of the treatments, and to establish if there was a significant difference in growth rates between the three treatments. To correct for size differences among rays in the three treatments, the replacement spine length of each *U. halleri* were normalized to each rays' disk width.

Histology

To determine the exact location of the primordial spine bud, caudal spine tissue samples were obtained for histological analysis from several *U. halleri* that were brought into the lab from June to October 2002. The primary and secondary (replacement) spines of the anaesthetized rays were surgically removed with a scalpel and the rays were kept for one week, after which the area encompassing the spine origin were excised and the rays released. The excised tissues were fixed in 5.0 % glutaraldehyde in Sorensen's phosphate buffer (pH 6.8) for two hours, and treated for two successive 18 hr periods with 1.0 % EDTA in the same buffered fixative. Tissues were rinsed (3 times—10 min each), postfixed for two hrs with 1.0 % OsO_4, and rinsed again in Sorensen's phosphate buffer (pH 6.8). Following dehydration with a cold, graded, ethanol series, the tissues were infiltrated with Spurr's epoxy resin. Sections (2 μm) for light microscopy were stained with methylene blue-azure II and basic fuchsin (Humphrey et al. 1974). Photomicrographs were taken using a Nikon Eclipse E800 microscope outfitted with an Olympus MagnaFire digital camera.

Results

Replacement Spine Development

In all treatment groups, the primordial spine bud appeared as a gelatinous, opaque, and grayish-purple differentiated tissue that eventually developed into the secondary spine. All *U. halleri* in the three treatment groups developed primordial spine buds by early July with the exception of two rays, one of which (removed treatment) showed a primordial bud in early June and the other (intact treatment) did not show a bud until mid July (Fig. 1). There was no significant difference in the onset of primordial spine bud eruption among the three treatments ($F = 2.14$, $p = 0.123$) (Fig. 1).

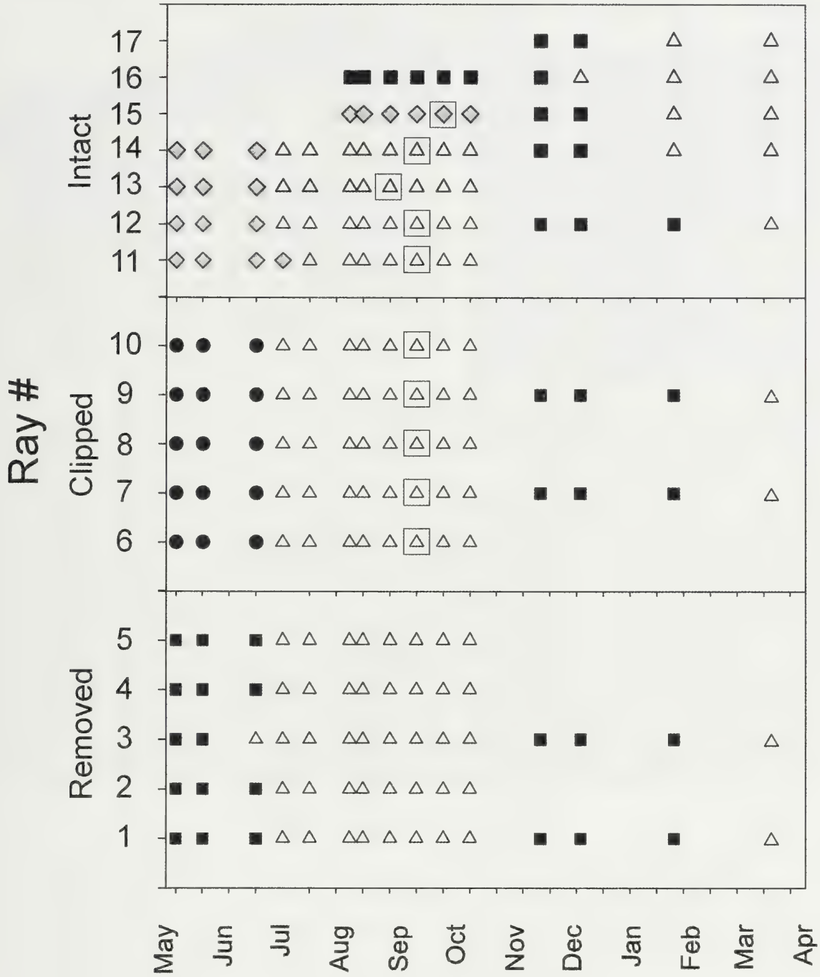

Fig. 1. Summary of the caudal spine replacement for round stingrays (#1–17) with removed (black square), clipped (black dot) and intact primary spines (gray diamond). White triangles indicate the dates when replacement spines were observed. Large box surrounding white triangles or gray diamond indicate the dates when the primary spines were shed. Ray 16 and 17 were added later to the intact treatment group.

Of the nine rays that had their spines removed again in November 2002, four developed a new primordial spine bud within 2.5 months. All rays had a noticeable new replacement spine within 4 months (Fig. 1).

Replacement Spine Growth Rate

All treatment groups exhibited a significant increase in replacement spine length over time ($F = 800$, $p < 0.0001$) and there was no significant difference in replacement spine growth rate among the three treatment groups ($F = 0.02$, $p = 0.984$) (Fig. 2a–c). One ray in the removed spine treatment developed twin replacement spines, which were first observed in August. The twin replacement spines separated from each other, with the ventral spine growing faster than the dorsal spine. However, the overall spine growth rate of these supernumerary

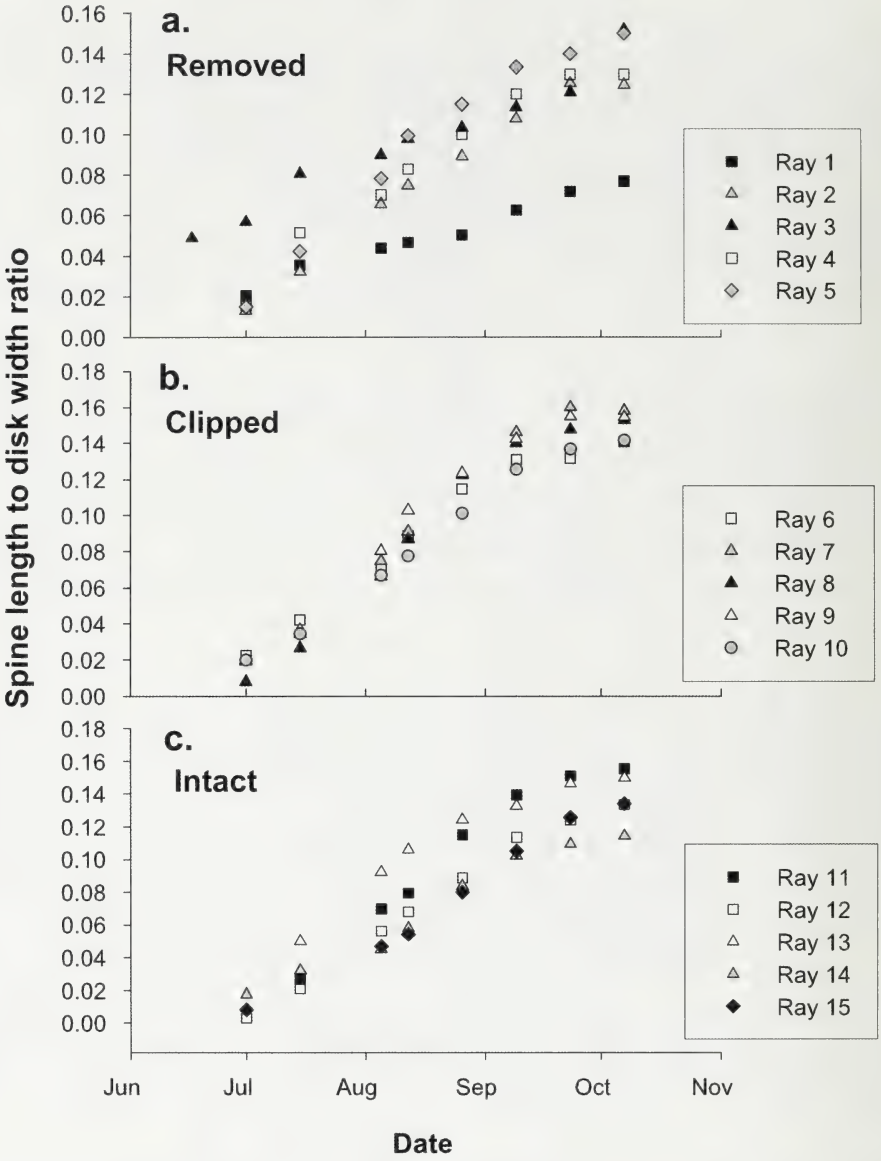

Fig. 2. Growth of replacement caudal spines of round stingrays for the three treatment groups. Spine length to disk width ratio represents the length of the replacement spine relative to the disk width of the ray. Figure 2a–c indicate a) removed primary spine treatment group, b) clipped primary spine treatment group, and c) intact (control) primary spine group.

spines was slower than that of the replacement spines of the other rays (Fig. 2a; Ray 1).

Replacement spines in all treatment groups continued to grow for approximately three months until spine length was about 14 % of the rays' disk width. At this time, the primary spines of the intact (control) and clipped spine treatment groups were shed, leaving the replacement spine as the new primary spine (Fig 1).

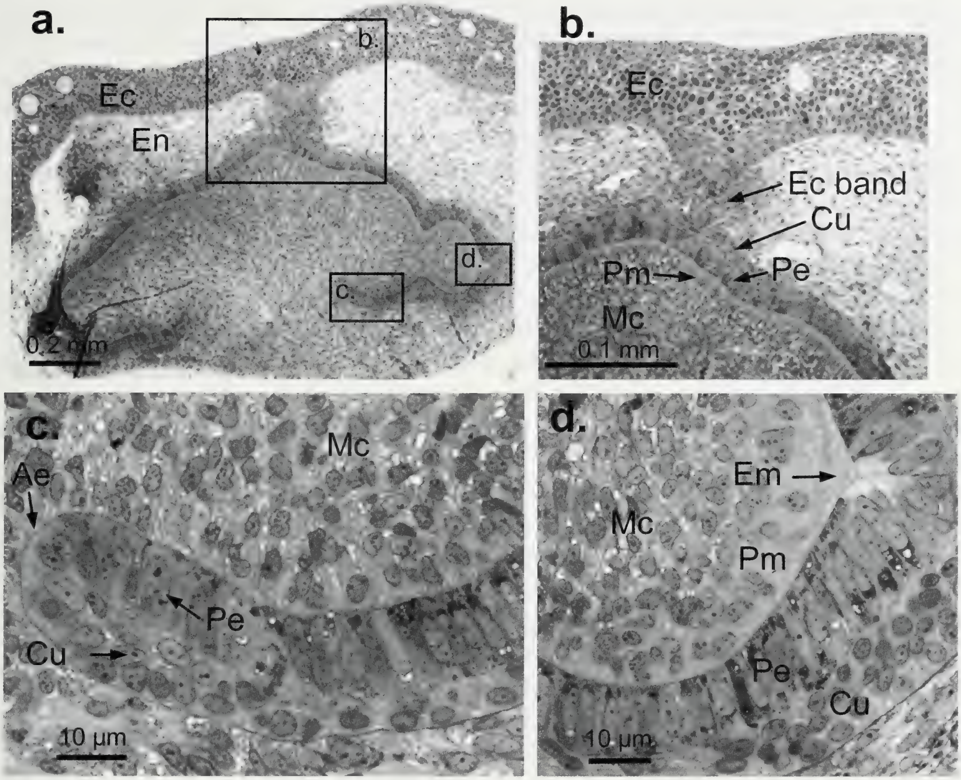

Fig. 3. Photomicrographs of primordial spine bud in the round stingray. a) A cross section of the dorsal surface of the tail of *Urobatis halleri* showing a developing spine primordium. The inserted boxes (b–d) indicate areas that are shown in figures 3b–d at higher magnification. Outer layer of ectoderm (Ec); endoderm (En); cuboidal ectoderm (Cu); ectodermally-derived pseudostratified columnar epithelium (Pe); mesodermally-derived pseudostratified columnar epithelium (Pm); mesenchymal-like cells (Mc); enameloid matrix (Em); and the advancing edge of the developing enamel organ (Ae).

Histology

The newly formed dorsal integument that gave rise to the spine bud in *Urobatis halleri* appeared as a gelatinous, opaque grayish-purple tissue. Histological analysis of this region indicated that spine formation began with the formation of a central, longitudinal depression in the ectoderm (Fig. 3a,b). A one to two cell thick band of basal layer cells, supported by an aggregation of mesenchymal cells, extended from this depression ventrally into the dermis (Fig. 3b). Primordial spine formation began a short distance into the dermis where this band bifurcated to form a sheet of more or less cuboidal cells. The advancement of this sheet's leading edges was at first primarily ventro-lateral, but then growth turned inward so as to enclose a region of the mesenchyme. As this sheet of cells progressed through the dermis, its advancing edges recurved upon themselves and gave rise to an interior adjacent layer of pseudostratified columnar epithelium (Fig. 3c). The cells of the columnar layer were characterized by the presence of large numbers of azurophilic secretory granules. These granules were predominantly located between the nucleus and the basement membrane, i.e. directed toward the medullary region of the developing spine. The ectoderm basal lamina was continuous throughout the aforementioned structures, i.e. from the basal ectoderm layer, through the band, around the germinative cell layer and interior to the columnar layer. A second layer of pseudostratified epithelium developed from mesenchymal cells along the basal lamina of the ectodermally derived pseudostratified epithelium. This second, more inner layer of pseudostratified epithelium contained only clear vacuoles, also located predominantly between the cell nucleus and basement membrane. Initial matrix secretion by the columnar epithelia was indicated by the deposition of a non-cellular material that caused the separation of the adjacent basement lamina (Fig. 3d). The interior of the spine primordium consisted mostly of mesenchymal-like cells. Here cell density was much higher than that observed in the surrounding dermis.

Discussion

Results from this study indicate that *Urobatis halleri* exhibit a seasonal spine shedding period, but can also replace spines that have been removed outside the typical spine replacement season. Rays in all treatments exhibited a primordial spine bud in mid summer (July), and those with intact or clipped primary spines shed their primary spines in September–October after the replacement spine was nearly the length of the primary. Rays that had their new seasonal spines removed in November, showed the development of a new primordial spine bud within 2.5–4 months. Rays collected in the field during the same months, exhibited similar stages in seasonal spine replacement and shedding, yet there was no sign of spine replacement observed for any rays in the field after November (Lowe et al. unpub. data). These findings support the hypothesis that *U. halleri* are able to replace lost spines; however, broken spines (clipped treatment) may not initiate the development of a replacement spine outside the typical spine replacement season. This suggests that there are two possible mechanisms involved in spine replacement in round stingrays. One mechanism allows for seasonal spine replacement, and therefore, could be cued by some environmental stimulus, such as day length or water temperature, while the other mechanism is likely initiated through some mechanical disturbance or damage to cells comprising the attachment site of the caudal spine.

During typical spine replacement, the newly-developing spine grows posterior to an existing functional spine, ensuring the ray has some defense during spine replacement. However, if a stingray should lose its primary functional spine, one might expect faster than normal replacement spine growth to provide the ray with a new protective spine as quickly as possible. Spine replacement growth rate did not significantly vary between treatments, indicating that rays with no functional spines (removed spine treatment) did not grow a replacement significantly faster than those with a fully functional spine (control). This suggests that spine replacement growth rate may be relatively fixed. The primordial spine buds of *U. halleri,* in all treatments, developed into full grown replacement spines in approximately three months. Similar growth rates have been observed in replacement placoid scales from wounds in both nurse and leopard sharks (Reif 1978). However, a slower replacement spine growth rate was observed in a female *U. halleri* (Ray 1) that developed a "twin" replacement spine. Although the presence of multiple spines (supernumerary) in some species of stingrays is common (Thorson et al. 1988), the occurrence of more than two spines in round stingrays is rare (Russel 1955, Lowe et al. unpubl.). The development of the twin replacement spine in the female ray may have reduced the growth of both spines.

The development of the primordial spine in *U. halleri* was similar to dermal denticles in the skate, *Leucoraja erinacea.* The first of two notable differences was that denticle laminae were found to form directly from basal ectoderm (Miyake et al. 1999), while the spine primordium was derived from a band-like ingrowth of the same tissue into the dermis. This modification in the growth pattern may be necessary to accommodate for the spine's considerably greater length. The two layers of ectoderm-derived cells that developed from the band-like ingrowth appeared similar to the outer- and inner-denticle epithelia of denticle papillae. Given their similar location and their large numbers of basally-directed secretion granules, the cells of the primordial spine's ectoderm-derived pseudostratified columnar epithelial layer may be identified as ameloblasts. Thus, this layer constitutes an enamel organ. The development in the spine primordium of a mesenchyme-derived more inner layer of well defined pseudostratified epithelium constitutes the second notable difference from the denticle papilla of *L. erinacea.* In the latter, cells within the mesenchyme, pre-odontoblasts, aggregated to form several poorly defined cell layers beneath an already established enameloid matrix. This clearly differs from the spine primordium where the mesenchyme cells adjacent to the enamel organ had taken the form of what appeared to be a well defined dentine organ prior to any matrix deposition. This latter arrangement is more akin to that which has been reported for shark scales (Nelsen 1953). It is possible that the presence of well developed enamel and dentine organs prior to matrix deposition may be linked to the initial patterning of the spine. This supposition is supported by the finding that matrix deposition first appears between the enamel and dentine organ. Once the pattern has been laid out, the spine's interior could then be strengthened by dentin deposition from odontoblasts derived from the prevalent mesenchyme-like cells located within the pulp of the developing spine.

Stingrays may have evolved several mechanisms for replacement of caudal spines. Seasonal spine replacement may be needed to produce larger spines as the ray grows larger. However, round stingrays can also replace their caudal spines out of season, as a result of a traumatic injury to the spine and its attachment site. This ability may be essential to provide the ray with some protection prior to the next normal spine replacement season. It is likely that rates of potential predation events must be significant enough to have driven the evolution of these separate spine replacement mechanisms.

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Literature Cited

Amesbury, E., Snelson, F. F. 1997. Spine replacement in a freshwater population of the Atlantic stingray, *Dasyatis sabina.* Copeia 1:220–223.

Campbell, B. 1951. The locomotor behavior of spinal elasmobranchs with an analysis of stinging in *Urobatis.* Copeia 4:277–284.

Gudger, E. W. 1932. Cannibalism among the sharks and rays. Scientific Monthly 34(5): 403–419.

———. 1946. Does the stingray strike and poison fishes? Scientific Monthly 63(2):110–116.

Halstead, B. W., Ocampo, R. R., Modglin, F. R. 1955. A study on the comparative anatomy of the venom apparatus of certain North American stingrays. J. Morphology 97(1): 1–12.

Humphrey, C. D., Pittman, F. E. 1974. A simple methylene blue-azure II-basic fuchsin stain for epoxy-embedded tissue sections. Stain Technology 49(1): 9–14.

Kemp, N. E. 1999. Integumentary system and teeth. In: Sharks, skates, and rays. The biology of elasmobranch fishes. W. C. Hamlett, ed. The Johns Hopkins University press, Baltimore.

Knopf, A. A. 2000. Field guide to fishes, whales, and dolphins. National Audubon Society.

Miyake, T., Vagila, J. L., Taylor, L. H., Hall, B. K. 1999. Development of dermal denticles in skates (Chondrichthyes, Batoidea): Patterning and cellular differentiation. J. Morphology 241:61–81.

Nelsen, O.E. 1953. Comparative embryology of the vertebrates. Blakiston, New York.

Quilhac, A., Sire, J. Y. 1999. Spreading, proliferation, and differentiation of the epidermis after wounding in a cichlid fish, *Hemichromis bimaculatus.* Anatomical Record 245:435–451.

Reif, W. E. 1978. Wound healing in sharks. Form and arrangement of repair scales. Zoomorphologie 90:101–111.

———. 1982. Evolution of dermal skeleton and dentition in vertebrates. The odontode regulation theory. In: Evolutionary biology, Vol 15. M. K. Hecht, B. Wallace, G. T. Prance, eds. Plenum press, New York.

Russel, F. E. 1953. Stingray injuries: A review and discussion of their treatment. Amer. J. Medical Science. 226:611–622.

———. 1955. Multiple caudal spines in the round stingray, *Urobatis halleri.* Calif. Fish & Game. 41: 213–217.

Teaf, C. M., Lewis, T. C. 1987. Seasonal occurrence of multiple caudal spines in the Atlantic stingray, *Dasyatis sabina.* Copeia 224–227.

Thorson, T. B., Langhammer, J. K., Oetinger, M. I. 1988. Periodic shedding and replacement of venomous caudal spines, with special reference to South American freshwater stingrays, *Potomotrygon* spp. Environmental Biology of Fishes 23(4): 299–314.

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Ecological Impacts of Seed-Harvester Ants on the Phenological Events of Seven Mojave Desert Shrub Species in Southern Nevada

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Abstract.—Ecological impacts of a seed-harvester ant (*Pogonomyrmex rugosus*) infestation on the phenological characteristics of surrounding seven Mojave Desert shrub species were quantitatively investigated in Las Vegas Valley of southern Nevada. These shrub species were Shockley's goldenhead (*Acamptopappus shockleyi*), white bursage (*Ambrosia dumosa*), shadscale (*Atriplex confertifolia*), Nevada ephedra (*Ephedra nevadensis*), winterfat (*Krascheninnikovia lanata*), range ratany (*Krameria erecta*), and creosote bush (*Larrea tridentata*). The initiation of leafing, flowering, and fruiting phenologies was significantly delayed, and flowering success was significantly reduced in all shrub species occurring within and around the nest area compared to the adjacent non-nest area. The interval between initial dates of each major phenophase (leafing, flowering, and fruiting) of all shrub species became larger in nest relative to non-nest areas. The infestation of seed-harvester ants had a detrimental effect on the phenological events of seven Mojave Desert shrub species in southern Nevada.

The seed-harvester ant (*Pogonomyrmex rugosus*) occurs in arid and semiarid plant communities throughout much of southwestern United States (Carlson and Whitford 1991). Nests of harvester ant species are generally clear of plants at least in the central area surrounding the single nest entrance where ant activities are most intense (Beattie and Culver 1977; Lei 1999). Previous studies have found changes in plant diversity and composition (Beattie and Culver 1977; Lei 1999), population densities (Hobbs 1985; Lei 1999), and vegetation production (Rogers and Lavigne 1974) associated with ant nests.

Studies of plant phenology are crucial to understand the resource base of populations, communities, and ecosystems. Phenological events of selected Mojave Desert shrub species were studied in Rock Valley of southern Nevada (Wallace and Romney 1972; Ackerman and Bamberg 1974; Beatley 1974; Rundel and Gibson 1996). Yet, ecological impacts of seed-harvester ants on the phenological attributes of the surrounding shrub species have not been documented in Las Vegas Valley. Rock and Las Vegas Valleys are similar in climatic conditions, species composition, vegetation cover, community structure, soils, geology, and topography. The objective of this study was to quantify leafing, flowering, and fruiting phenologies of all seven Mojave Desert species—Shockley's goldenhead (*Acamptopappus shockleyi*), white bursage (*Ambrosia dumosa*), shadscale (*Atriplex confertifolia*), Nevada ephedra (*Ephedra nevadensis*), winterfat (*Krascheninnikovia lanata*), range ratany (*Krameria erecta*), and creosote bush (*Larrea tri-*

Table 1. Mean monthly air temperature and precipitation of Las Vegas Valley from the years 2000–2003 (NOAA, Las Vegas). Official weather data were obtained from the McCarran Airport in Las Vegas, near my study site. The letter "T" indicates trace precipitation, an amount greater than zero but less than the lowest reportable value.

Month	Air temperature (°C)	Precipitation (mm)
January	10.3	T
February	11.3	1.4
March	14.7	3.7
April	19.9	3.3
May	25.6	T
June	31.2	T
July	34.4	13.6
August	32.5	7.6
September	28.3	7.1
October	21.1	10.4
November	11.8	6.1
December	9.0	9.1

dentata), occurring in the nest area compared to the adjacent non-nest area in Las Vegas Valley.

Methods

Study Site

The field study was conducted in the southwestern part of Las Vegas Valley in southern Nevada (36°04′N; 115°10′W). The climate is arid with hot, dry summer and cool, episodic wet winters. The mean monthly air temperature and precipitation for the years 2000 through 2003 are shown in Table 1 (NOAA, Las Vegas). The mean length of the frost-free period is over 350 days, and frequently an entire winter month will pass without a subfreezing air temperature. The mean annual rainfall is 10.1 cm (NOAA, Las Vegas), and most of the precipitation results from monsoonal thunderstorms in summer and drizzles in winter months. Often, a single major thunderstorm will contribute the rainfall for an entire month.

Vegetation of Las Vegas Valley was classified as creosote bush-white bursage association. Other woody taxa that were present in the nest area included Shockley's goldenhead, shadscale, Nevada ephedra, winterfat, and range ratany. Soils, derived from limestone-dolomite mountains and hills, are sandy in texture with loose rocks on the surface (Lei 2001a). Multiple caliche layers are found in the subsoil. Organic decomposition and soil formation are slow due to the arid nature of this area.

Field Survey

All 187 seed-harvester nests were identified in a 5-ha study plot. Each ant nest had multiple entrances, with a construction of subterranean chambers (cavities) and runways. Diameters of the exposed soil surface (disc) at each ant nest were measured in centimeters by computing the average of length and width of the nest.

Phenological observations were taken weekly in the nest and adjacent non-nest (control) areas from late January 2000 through the growing season in July 2003. A two-lane road separated the nest and non-nest areas. For each of the seven shrub species, initial dates of each phenophase (appearance of new leaves, flowers, and mature fruits) were observed among any of the 40 randomly chosen individual plants in the study plots. Each individual plant was marked with brightly colored flagging for ease of visualization in subsequent months and years. Subsequent periods of each phenophase later in the season were not evaluated or considered.

Moreover, within each shrub species, flowering success (percentages of mature flower cover) was assessed in these 40 randomly chosen individuals. Percentages of flower cover were visually quantified in 10% point increments (Lei 2001b).

Statistical Analysis

Mean diameter of ant nests was computed in centimeters. Significant differences in mean initial dates of phenological events and flowering success were tested with one-way Analysis of Variance (ANOVA; Analytical Software 1994) between nest and adjacent non-nest areas. Julian day calendar, a calendar system that numbers days consecutively instead of using cycles of days and months, was used for ease of computation. Nevertheless, results were converted back to the standard calendar system for ease of interpretation and comprehension. Mean values were expressed with standard errors, and statistical significance was determined at the 5% level.

Results

The mean diameter of ant nests (disc) was 85.6 ± 9.4 cm (n = 187). In general, initial dates of phenophases between shrubs occurring in nest and non-nest areas ranged over periods of 2–5 weeks. All seven shrub species consistently exhibited a significant delay in vegetative, floral, and reproductive phenologies in the nest area compared to the adjacent non-nest area (Tables 2–4). With the presence of active ant nests, the average time between first appearance of leaves and first mature flowers, as well as between first appearance of flowers and first mature fruits of these shrub species was considerably longer.

Among all shrub species, Nevada ephedra exhibited the earliest mean initial dates of phenophases irrespective of ant infestation (Tables 2–4). Creosote bush, shadscale, and Nevada ephedra grew continuously when most shrubs underwent summer dormancy in typical dry years. Range ratany balanced its late growth with an initial leafing approximately 4–7 weeks later than all other shrub species (Table 2). Range ratany did not develop mature fruits until the end of June (Table 4).

All seven shrub species initiated flowers eight weeks after the initial date of leafing irrespective of ant infestation (Tables 2–3). Flowering of range ratany and creosote bush was considerably later than the other five shrub species (Table 3). The interval between first appearance of leaves and first flowers was five weeks in Nevada ephedra. Creosote bush and white bursage formed leaves early, but flowered approximately eight weeks after leaf initiation in both nest and adjacent non-nest areas (Tables 2–3). In all seven shrub species, leaf and flower production overlapped during the spring months. Ripe fruits were first observed approximately 2–3 weeks after flower initiation in the non-nest area, and 3–4 weeks in the nest area (Tables 3–4).

Table 2. Mean initial dates of leafing in seven Mojave Desert shrub species occurring in the nest and adjacent non-nest (control) areas in Las Vegas of southern Nevada. Mean dates are presented with standard errors, and statistical significance is determined at $p \leq 0.05$ using one-way ANOVA.

Species	Non-nest	Nest	F-value	p-value
Creosote bush	March 6 ± 4	March 27 ± 5	13.29	0.0109
Shockley's goldenhead	March 11 ± 4	March 29 ± 5	9.72	0.0206
Nevada ephedra	February 19 ± 3	March 3 ± 4	17.15	0.0063
Range Ratany	April 2 ± 5	April 28 ± 5	20.28	0.0041
Shadscale	February 26 ± 4	March 28 ± 4	27.00	0.0020
Winterfat	March 7 ± 4	March 29 ± 6	14.52	0.0089
White bursage	February 17 ± 4	March 9 ± 4	12.00	0.0134

Furthermore, flowering success was significantly reduced in all seven shrub species occurring within and around disc perimeters compared to the non-nest area (Table 5). Mean flower cover was under 20% for shrubs occurring in the nest area, while mean flower cover was between 30 to 45% for shrubs occurring in the non-nest area. Percent flower cover ranged from 12.1% in Nevada ephedra in the nest area to 40.8% in creosote bush in the non-nest area (Table 5).

Discussion

Initiation dates of three important phenophases—appearance of leaves, appearance of flowers, and development of fruits—of seven Mojave Desert shrub species were quantitatively investigated in Las Vegas Valley of southern Nevada. Observations of phenological patterns were considered typical for the species in this study. This study demonstrated a substantial variation in phenological timing among seven shrub species occurring in the non-nest area, and phenological events of these species were significantly delayed by as many as 3–4 weeks due to ant infestation.

In this study, seed-harvester ants locally influenced plants beyond the nest (disc) area as evidenced by delayed phenological events in the nest area compared to the adjacent non-nest area. From casual observations, numerous ants were found on stems, leaves, and flowers of shrubs occurring within and around the periphery of nest discs. Through time, portions of shrub leaves were defoliated by ants. Rissing (1988) also observed the defoliation of creosote bush leaves by seed-harvester ants in southern Nevada. Clark and Comanor (1975) stated that the

Table 3. Mean initial dates of flowering in seven Mojave Desert shrub species occurring in the nest and adjacent non-nest (control) areas in Las Vegas of southern Nevada. Mean dates are presented with standard errors, and statistical significance is determined at $p < 0.05$ using one-way ANOVA.

Species	Non-nest	Nest	F-value	p-value
Creosote bush	May 2 ± 4	May 28 ± 5	20.18	0.0041
Shockley's goldenhead	April 26 ± 5	May 15 ± 4	10.83	0.0166
Nevada ephedra	March 27 ± 4	April 19 ± 4	15.87	0.0073
Range ratany	May 15 ± 4	June 3 ± 5	6.34	0.0473
Shadscale	April 6 ± 5	May 12 ± 4	38.88	0.0008
Winterfat	April 19 ± 3	May 5 ± 6	7.68	0.0324
White bursage	April 14 ± 3	May 17 ± 5	16.43	0.0067

Table 4. Mean initial dates of fruiting in seven Mojave Desert shrub species occurring in the nest and adjacent non-nest (control) areas in Las Vegas of southern Nevada. Mean dates are presented with standard errors, and statistical significance is determined at $p \leq 0.05$ using one-way ANOVA.

Species	Non-nest	Nest	F-value	p-value
Creosote bush	May 13 ± 4	June 10 ± 5	23.52	0.0029
Shockley's goldenhead	April 24 ± 5	June 9 ± 4	60.75	0.0002
Nevada ephedra	April 19 ± 4	May 16 ± 4	23.85	0.0028
Range ratany	June 7 ± 4	June 30 ± 5	7.31	0.0407
Shadscale	April 24 ± 5	May 29 ± 4	36.75	0.0009
Winterfat	May 8 ± 5	June 4 ± 6	20.08	0.0042
White bursage	May 9 ± 3	June 12 ± 5	32.51	0.0013

majority of harvester ant species in the genus *Pogonomyrmex* may actively defoliate leaves and destroy plants growing on and near their nests in order to reduce shade because high nest temperatures are required for brood development. Plants must allocate their limited energy to growth, survival, and reproduction. Because of an extensive defoliation by ant activities, shrubs must expend some energy to withstand ant infestation and grow additional leaves prior to flowering and fruiting development. Consequently, the flowering and reproductive success of these seven shrub species is substantially reduced. No comparative data are available since ecological impacts of ant infestation on shrub phenology have not been quantitatively examined elsewhere in the Mojave Desert.

The disc is a visually obvious nest structure, but not the limits of the nest itself, which may extend below the soil surface at a distance beyond the disc (Lei 1999). Furthermore, seed-harvester ant nests influence the soil surface beyond the limits or physical structure of the nest disc as well.

Variations have been documented in phenological timing among shrub species and from year to year in Rock Valley of southern Nevada (Ackerman and Bamberg 1974; Beatley 1974; Rundel and Gibson 1996) regardless of seed-harvester ant infestation. In springs of 2000–2003, mean leaf initiation of range ratany was 4–7 weeks later than other shrub species in Las Vegas Valley. Flowering in most species was commenced about 4–6 weeks following leaf initiation, and fruiting was commenced approximately 2–3 weeks following flower initiation (Rundel and Gibson 1996), which concur with this study. Moreover, the interval between

Table 5. Flowering success (mean percent flower cover per individual plant) of seven Mojave Desert Shrub species occurring in the nest and adjacent non-nest (control) areas in Las Vegas of southern Nevada. Mean values are presented with standard errors, and statistical significance is determined at $p \leq 0.05$ using one-way ANOVA.

Species	Non-nest	Nest	F-value	p-value
Creosote bush	40.8 ± 4.3	17.6 ± 2.9	47.21	0.0001
Shockley's goldenhead	30.3 ± 3.5	13.9 ± 3.4	10.62	0.0115
Nevada ephedra	25.5 ± 3.2	12.1 ± 3.0	19.71	0.0022
Range ratany	31.2 ± 3.4	18.8 ± 2.6	9.54	0.0149
Shadscale	30.2 ± 3.7	12.4 ± 1.9	26.19	0.0009
Winterfat	33.1 ± 3.4	19.3 ± 2.8	32.06	0.0005
White bursage	39.4 ± 3.7	15.3 ± 3.2	24.74	0.0011

initial dates of each major phenophase of all seven shrub species became larger due to ant infestation in this study.

This study examines how active seed-harvester ant colonies have adversely affected the phenology of Mojave Desert shrub species. In order to completely understand the phenology of Mojave Desert shrub species, additional field research studies are required when attempting to formulate generalizations based on the phenological data of the Mojave Desert shrub species in southern Nevada.

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Literature Cited

Ackerman, T.L. and Bamberg, S.A. 1974. Phenological studies in the Mojave Desert at Rock Valley (Nevada Test Site). Pp. 215–226 in: Lieth, Helmet (ed.). Phenology and seasonality modeling. Springer-Verlag. New York.

Analytical Software. 1994. Statistix 4.1, an interactive statistical program for microcomputers. Analytical Software. St. Paul, Minnesota. 329 pp.

Beatley, J.C. 1974. Phenological events and their environmental triggers in a Mojave Desert ecosystem. Ecology 55:856–863.

Beattie, A.J. and Culver, D.C. 1977. Effects of the mound nests of ant, *Formica obscuripes,* on the surrounding vegetation. American Midland Naturalist 97:390–399.

Carlson, S.R. and Whitford, W.G. 1991. Ant mound influence on vegetation and soil in a semiarid mountain ecosystem. American Midland Naturalist 126:125–139.

Clark, W.H. and P.L. Comanor. 1975. Removal of annual plants from the desert ecosystem by western harvester ants, *Pogonomyrmex occidentalis.* Environmental Entomology 4:52–56.

Hobbs, R.J. 1985. Harvester ant foraging and plant species distribution in annual grassland. Oecologia 67:519–523.

National Oceanic and Atmospheric Administration. 2000–2003. Local climatological data: Annual summary with comparative data, Las Vegas, Nevada. National Climatic Data Center. Ashville, North Carolina.

Lei, S.A. 1999. Ecological impacts of *Pogonomyrmex* on woody vegetation of a *Larrea-Ambrosia* shrubland. Great Basin Naturalist 59:281–284.

Lei, S.A. 2001a. Ecological impacts of seed-harvester ants on soil attributes in a *Larrea*-dominated shrubland. Western North American Naturalist 60:439–444.

Lei, S.A. 2001b. Diversity of parasitic *Cuscuta* and their host plant species in a *Larrea-Atriplex* ecotone. Southern California Academy of Sciences 100:36–43.

Rissing, S.W. 1988. Seed-harvester ant association with shrubs: competition for water in the Mojave Desert? Ecology 69:809–813.

Rogers, L.E. and Lavigne, R.J. 1974. Environmental effects of western harvester ants on the shortgrass prairie ecosystem. Environmental Entomology 3:994–997.

Rundel, P.W. and Gibson, A.C. 1996. Ecological communities and processes in a Mojave Desert ecosystem: Rock Valley, Nevada. University Press. Cambridge, Massachusettes. 369 pp.

Wallace, A. and E. Romney. 1972. Radioecology and ecophysiology of desert plants at the Nevada Test Site. TID-25954. US AEC Technical Information Center. Oak Ridge, Tennessee.

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Preferential Burrow Entrance Placement in the Dulzura Kangaroo Rat, *Dipodomys simulans*

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Abstract.—This study examined burrow location preferences in the Dulzura kangaroo rat, *Dipodomys simulans.* Burrow entrances known to be occupied by individual kangaroo rats on two experimental sites were identified and the distances to the nearest shrub were determined. These data were then compared to a distribution of random points delineated on those same plots to test whether this species appears to have a spatial preference for burrow placement in relation to vegetative cover. The results suggest that this species prefers to locate its burrow entrances in the open, but within 2 m of vegetative cover.

Kangaroo rats generally coexist with several species of murids including deer mice, *Peromyscus* spp, and wood rats, *Neotoma* spp (Brown and Leiberman 1973; Rosenzweig and Winakur 1969). Other studies report coexistence with other heteromyids, the pocket mice, *Perognathus* spp. and *Chaetodipus* spp. (Jones 1993; Brown and Harney 1993; Thompson 1982). The structure of these rodent communities appears to be organized with microhabitats and food resources partitioned in such a manner that abundant and diverse species may be maintained. Brown and Munger (1985) showed that the population density of smaller seed-eating rodents increases after removal of the local kangaroo rat population, indicating that competition for resources may be responsible for the structure of these communities.

Cover utilization also seems to be an important factor in determining community structure, with some heteromyids preferring open areas, some dense cover, and others seeming to have no preference. Experiments have shown that the distribution of species in a community can be altered by artificially manipulating the density of cover (Rosenzweig 1973). Rosenzweig and Winakur (1969) found that the kangaroo rats *Dipodomys merriami* and *D. spectabilis* prefer open areas for foraging, whereas the pocket mice tend to utilize dense cover almost exclusively for this purpose. Rosenzweig (1973) further states that this difference in habitat use patterns is crucial to their coexistence. Other studies support these findings, reporting that another species of kangaroo rat (*D. deserti*) also prefers to forage in the open and that this choice is made in response to competitive pressure from coexisting pocket mice (Eisenberg 1963).

Kangaroo rats possess adaptations such as large auditory bullae tuned to low frequencies (Lay 1993), bipedality, and eyes located dorsolaterally, all of which enhance the animals' ability to escape predation (Thompson 1982). With these adaptations, kangaroo rats have an advantage over other coexisting rodent species, enabling them to better exploit open habitats.

Although there has been substantial work done on foraging habits of heteromyids in relation to vegetative cover, there appears to be very little concerning burrow site selection in relation to vegetative cover. Tremor and Haas (2000) report that *D. merriami* maintains multiple entrances to a complex burrow system that it preferentially places at the base of shrubs. The Texas kangaroo rat, *D. elator,* places its burrow at the base of mesquite plants, often with the root system forming one side of the entrance (Davis and Schmidly 1997).

In this report, Dulzura kangaroo rat (*Dipodomys simulans*) burrow entrance location data collected during a food augmentation study conducted by Yvonne Moore were utilized to examine spatial dispersion of burrow entrances in relation to vegetative cover.

Methods

I studied burrow locations at two sites in Riverside County, California where Moore has conducted long-term studies: one at the Motte Rimrock Reserve in Perris, the other at the Shipley Ecological Preserve in Hemet. Both sites consist of coastal sage scrub with the Motte Reserve dominated by California buckwheat (*Eriogonum fasciculatum*), brittle bush (*Encelia farinosa*), and black sage (*Salvia mellifera*). Buckwheat, white sage (*S. apiana*), and the wild flower (*Keckiellia antirrhinoides*) dominate the Shipley Preserve. At the Motte Reserve, eight plots (Plots 1–8), each 40 by 40 m with a 5 by 5 grid of live-trapping stations spaced 10 m apart, had been previously established by Moore. There were four plots at the Shipley Preserve, each 50 by 60 m with a 6 by 7 grid of live-trapping stations spaced 10 m apart (Plots 13, 14, 18, and 20).

Burrow entrance data were obtained from Moore, who used methods described by Boonstra and Craine (1986) to track animals back to their burrows upon release. The method employs silk thread bobbins attached to the hindquarters of the animals with glue. The loose end of the thread is tied to a stake or branch and the animal is left to make its way back to its burrow, sometimes after further foraging. The thread can later be traced to the burrow. The burrows were then numbered and flagged for future focal trapping.

The present study characterized burrow entrances as either under the cover of shrubs, or in the open (beyond the dripline of a shrub). The location of burrows in the open was measured as the distance from the center of the burrow entrance to the dripline of the nearest shrub. For this study I characterized cover as that which would appear to effectively conceal rodents from predators. Therefore, shrubs were only considered cover if their foliage and branches exceeded 1 cubic foot or $(30\text{ cm})^3$ in volume.

In order to obtain a random distribution of points to use for comparison to the actual burrow locations, 240 random numbers between 0 and 1 to six decimal places were generated using Microsoft Excel in which numbers are generated from a uniform distribution. These numbers were then divided evenly into two separate columns, and designated as x and y coordinates. Next, both columns were divided into groups of ten, giving twelve sets of ten rectangular coordinates, one set of 10 pairs for each plot. Each column was then multiplied by the dimensions of its corresponding plot producing a system in which every point in the plot was potentially represented. The perimeter boundaries of two sides of each plot were delineated by driving stakes at three corners of the plot and then pulling twine along two perpendicular sides and tying it to the stakes. These lines were used as x and y-axes from which the random points could be measured. Ten random points were determined on each plot, and then the distance from each point to the nearest shrub was measured using the same criteria as that used for the actual burrows.

The statistical computer software package used to analyze all the data of this project was JMP, by SAS Institute Inc.

All data were tested for normality using the Shapiro-Wilk *W* Test. The data for actual burrow location distances from the nearest shrub were non-normal ($W = 0.7027$, $P < 0.0001$). Random point data also were non-normal ($W = 0.7398$, $P < 0.0001$). Therefore, all data were log-transformed [ln(distance+1)] and tested for normality. The transformed data were still distributed non-normally: burrows $W = 0.9228$, $P < 0.0001$; random points $W = 0.7610$, $P < 0.00001$. Non-parametric statistical methods were then employed to analyze the data in three ways:

1. The Mann-Whitney *U* test was used for the two-sample test between the burrow and random data for the single *combined* data set.
2. Differences between burrow and random points on each *individual* plot were also tested using the Mann-Whitney *U* test.
3. In order to test the difference in burrow placement *between* plots, the Kruskal-Wallis test was used.

Results

1. Combined data set: Overall, the pattern of burrow distribution differed significantly from the random distribution when all data were analyzed together ($U_{0.05(1),74,120} = 18.344$, $P < 0.0001$, $S.D._{burrow} = 0.968$, $S.D._{random} = 0.477$). This indicates that this species of kangaroo rat generally prefers to locate its burrows in a non-random fashion, favoring open areas to those beneath the vegetative canopy.

2. Individual plots: Actual burrow entrance measurements from each plot were compared with those random point distributions from the same plot (note: there were no burrows recorded on plot 4). These results varied from plot to plot (Table 1). There were significant differences in Plots 1, 2, 5, 7, 14, and 18 between burrow and random point distances to nearest shrub. Plot 7 had the greatest difference ($U_{0.05(1),5,10} = 9.912$, $P = 0.0008$) with a mean burrow distance from shrub cover of 0.832 m ($n = 5$) and all ten random points located under cover (mean random point distances to nearest shrub = 0.0, Table 1).

Plots 3, 6, 8, 13, and 20 did not differ significantly. However, Plots 3 and 6 had only two and three burrows respectively, so the Mann-Whitney *U* test had very little power to detect differences (Table 1).

3. Between plot analysis: Burrow-to-shrub distances for each plot were compared to test for between plot variation. The non-parametric Kruskal-Wallis test showed no significant difference ($X^2_{0.05} = 14.801$, $P = 0.1395$) (Note: Since plot 4 had no burrows, 11 plots are left in the analysis, and H is approximated by X^2 with 10 df.).

Plot 1 had an uncharacteristically high mean distance (mean = 2.286 m) due

Table 1. Descriptive statistics (means, S.D. and N) of individual plot data sets and that of the combined data set. Included are the P values obtained using the Wilcoxon Rank Sums Test.

Plot	Burrow Means (m)	S.D. (m)	n	Random Point Means (m)	S.D. (m)	n	P value
1	2.286	1.93	8	0.43	0.34	10	0.006*
2	0.5082	0.12	6	0.14	0.25	10	0.003*
3	0.4575	0.22	2	0.64	0.60	10	0.394[a]
4	No burrows	0.00	0	0.73	0.51	10	[a]
5	0.7622	0.66	6	0.18	0.27	10	0.016*
6	0.3557	0.38	3	0.27	0.51	10	0.192[a]
7	0.8320	0.52	5	0.0[b]	0.00	10	0.001*
8	0.6553	0.77	12	0.66	0.84	10	0.907
13	0.5182	0.59	5	0.2042	0.24	10	0.205
14	0.3963	0.35	10	0.1676	0.23	10	0.048*
18	0.5791	0.50	11	0.2743	0.42	10	0.048*
20	0.3048	0.39	6	0.2743	0.41	10	0.405
Combined	0.7537	0.96	74	0.3307	0.47	120	<0.000*

* Indicates significant differences.

[a] Indicates plots with n<5.

[b] Plot 7 mean random distance from shrub is 0.0 because all points landed under canopy.

to three outliers of 3.05, 3.66, and 6.10 m. All remaining plots had mean distances between 0.3 m and 0.9 m. Sparse vegetation on plot 1 could be responsible for this distribution. If this were the case, it should also be reflected by the random distribution. However, of the 10 random points on Plot 1, none was greater than 1 m from the nearest shrub cover. Burrows located more than 1 m from cover were unusual in this study, occurring only on Plot 1 and representing 16% of burrow data. Only 4% of the total burrow data set was beyond 3 m. It should also be noted that 23% of the burrows measured were under cover, while 55% of the random points landed under shrubs (Figure 1). Forty-nine percent of the burrows were within 1 m of cover and 65% between 0 and 2 m. Of the random points, 33% were within 1 m and 44% were between 0 and 2 m. There was only one random point beyond 2 m from cover (<1%), whereas 8% of the actual burrow entrances were beyond 2 m from cover (Figure 1). These data indicate a preference for burrow placement at distances of less than 2 m, but not under the canopy of the nearest shrub.

Discussion

Evidence provided by this study indicates that *D. simulans* places its burrows in a non-random fashion, favoring open areas to those under the canopy. This is indicated by the individual plot data as well as the combined data set. These findings suggest that this kangaroo rat has different burrow site selection requirements than those reported for *D. merriami* (Tremor and Haas 2000) and for *D. elator* (Davis and Schmidly 1997). These sources reported that the distribution was non-random, but the preference for burrow entrance locations was near the base of shrubs, rather than in the open.

On all plots, except Plot 3 and 8, the trend was that the mean burrow distances were greater than those of the random points. The data from all plots combined (Table 1) indicate a preference for burrow entrances located within 1 m of the

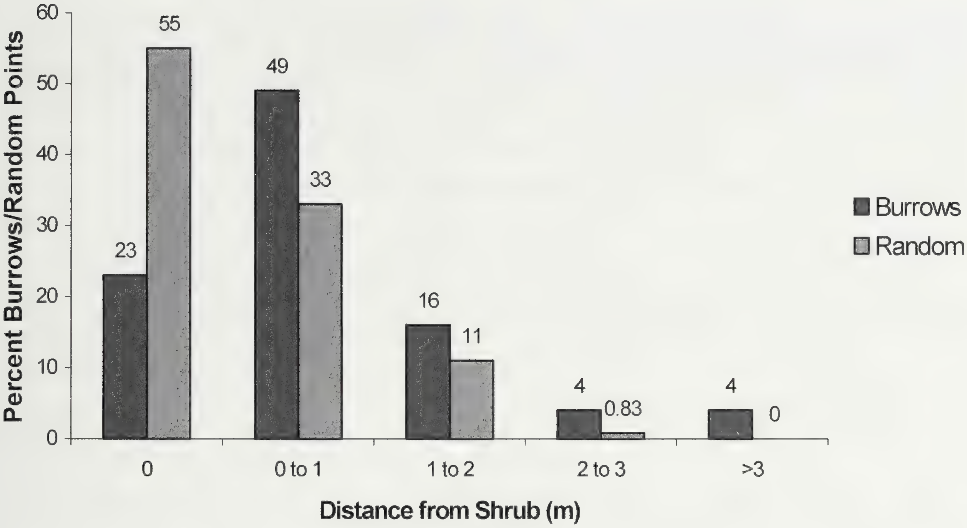

Fig. 1. Percentage of total number of burrows or random points from each data set at various distances to cover.

nearest shrub, but not directly beneath shrub cover. Whether or not these trends are due to spatial partitioning as the result of interspecific competition for higher quality sites is not known. The data suggest that preference of this species for open areas leaves a majority of the areas under the canopy open for settlement by its competitors, *Chaetodipus* and *Perognathus*. Jones (1993) reports that most heteromyids defend their burrows and burrow defense is an indication of competitive pressure.

In order to address the question of what is influencing *D. simulans* to choose open areas for burrow entrance placement, a study similar to this one should be conducted on the species of pocket mice coexisting with them. If the *Chaetodipus* and *Perognathus* species are indeed making use of the areas under the canopy of the local vegetation for their burrows, then it will be possible to design a study to test whether this preference is due to interspecific competition. By altering the structure of the shrub cover in an area selected for its occupation by a community with a known distribution of these heteromyids, and observing any changes in the distribution and abundance of these species over time, it should be possible to determine what factors influence the decisions these animals make in regards to burrow placement.

Although this study did detect trends in burrow placement in relation to the nearest shrub cover, spatial distribution, density, and species composition of the local vegetation were not quantified. An examination of these features might demonstrate whether or not this kangaroo rat has a preferred shrub species or a preferred side of the shrub. This may be important if the burrow is north of the nearest shrub because on a moonlit night the shrub might shield the burrow entrance from the moonlight, thereby making it safer for the kangaroo rat to emerge.

It also would be interesting to study a location with a different composition of heteromyids to see how resources are partitioned. Does the larger species exploit the open areas in other regions with a different species composition? Is it typically the kangaroo rats that prefer the open areas for placement of their burrows?

Finally, do these same patterns apply to other taxonomic groups as well? If so, perhaps optimality and game theory models can be applied to this system so that predictions can be made about the behavior of these rodent communities just by having some information on the species composition.

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Literature Cited

Boonstra, R., and I. T. M. Craine. 1986. Natal nest location and small mammal tracking with a spool and line technique. Can. Jour. Zoology 64:1034–1036.

Brown, J. H., and B. A. Harney. 1993. Population and community ecology of heteromyid rodents in temperate habitats. *In* Biology of the Heteromyidae. The Amer. Assoc. of Mammalogists, H. H. Genoways and J. H. Brown (ed.) Albuquerque, New Mexico, pp. 618–651.

———, and G. Leiberman. 1973. Resource utilization and coexistance of seed-eating rodents in sand dune habitats. Ecology 54(4):788–797.

———, and J. C. Munger. 1985. Experimental manipulation of a desert rodent community: food addition and species removal. Ecology 66(5):1545–1563.

Davis, W. B. and D. J. Schmidley. 1997. The Mammals of Texas: Online Edition. Texas Tech University. Available at: www.nsrl.ttu.edu/tmot1. Accessed 26 June 2003.

Eisenberg, J. F. 1963. The behavior of heteromyid rodents. Univ. of Calif. Pub. Zoology 69:1–100.

Jones, W. T. 1993. The social system of heteromyid rodents. *In* Biology of the Heteromyidae. The Amer. Assoc. Mammalogists, H. H. Genoways and J. H. Brown (ed.) Albuquerque, New Mexico, pp. 575–595.

Lay, D. M. 1993. Anatomy of the heteromyid ear. *In* Biology of the Heteromyidae. The Amer. Assoc. Mammalogists, H. H. Genoways and J. H. Brown (ed.) Albuquerque, New Mexico, pp. 270–289.

Rosenzweig, M. L. 1973. Habitat selection experiments with a pair of coexisting heteromyid rodent species. Ecology 54(1):111–117.

———, and J. Winakur. 1969. Population ecology of desert rodent communities: habitats and environmental complexity. Ecology 50(4):558–572.

Thompson, S. D. 1982. Microhabitat utilization and foraging behavior of bipedal and quadrupedal heteromyid rodents. Ecology 63(5):1303–1312.

Tremor, S. and B. Haas. 2000. *Dipodomys merriami*: Merriam's Kangaroo Rat. San Diego Natural History Museum. Available at: www.oceanoasis.org/fieldguide/dipo-mer.html. Accessed 26 June 2003.

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Age and Growth of Young-Of-The-Year (YOY) California Halibut (*Paralichthys californicus*), from Northwestern Baja California

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Abstract.—Ninety-nine young-of-the-year (YOY) California halibut (*Paralichthys californicus*), collected from Bahía de Todos Santos (BTS, n = 29), Estero de Punta Banda (EPB, n = 36) and Bahía de San Quintín (BSQ, n = 34), Baja California (México), were aged using sagittal otoliths. Our preliminary age determination by use of annual increments in otoliths of California halibut from Bahía de Todos Santos, and Estero de Punta Banda, Baja California (México), showed that a minimum length of 180 mm SL could be set as limit size for halibut young-of-the-year. The separate age-length relationships between YOY halibut from these three study sites are described by linear equations: BTS: $y = -4.943 + 0.5x$, $r^2 = 0.899$; EPB: $y = -12.85 + 0.496x$, $r^2 = 0.903$; BSQ: $y = -28.19 + 0.519x$, $r2 = 0.967$. The "y" is the standard length (mm) and the "x" is the age in days. Age was equivalent to the days from hatching. The Analysis of Covariance indicated no significant differences in growth rates between the three sites (ANCOVA, $p = 0.419$). Therefore, all data were combined to determine one overall growth equation for young-of-the-year: $y = -14.09 + 0.492x$, ($n = 99$, $r^2 = 0.907$, S.E. constant = 6.25, S.E. slope = 0.059). This equation established a limit size for young-of-the-year halibut as 173 mm SL, with a range of readings between 168 to 180 mm.

Introduction

Many recreational and commercial fishes, such as the California halibut *Paralichthys californicus,* spend some or all of their lives in nearshore water (Kramer 1990; Sears-Hartley 1994; Rosales-Casián 1997a).

Off California and northern Baja California, California halibut spawn primarily in February–March and secondarily between July–October. However farther south in Bahía de Sebastián Viscaino, a reversal pattern has been found with the most spawning in summer and lesser amounts in winter (Moser and Watson 1990). It is likely that more than two-thirds of the larval California halibut production occurs in Mexican waters (Moser and Watson 1990). In southern California, greatest densities of halibut young-of-the-year (YOY) occur in such protected habitats as bays and estuaries; one-half to one quarter of those densities were found in semi-protected environments, and very few individuals in open-coast sites (Allen et al 1990). However, in southern California most shallow water and bay habitats for halibut YOY have been destroyed or severely impacted by human activities (Kramer 1990).

Bahía de Todos Santos, Baja California, México is considered the southern extreme of the Southern California Bight, In their waters, the greatest abundance of larval California halibut was detected in March, and the maximum of post-flexion larvae near to bottom and close to shore was in July (Hammann and Ramirez-Gonzalez 1990). In Estero de Punta Banda, a part of the Bahía de Todos Santos system, halibut (primarily juveniles) were the most important species according to both abundance and frequency of occurrence (Rosales-Casián 1997a), and considerable movement between bay and estuary was detected (Rosales-Casián, 1997b).

The aging of California halibut YOY by using the microstructure of sagittal otoliths has been determined by Allen et al (1990), but they set a maximum size at 80 mm SL. Jensen (1990) working with YOY halibut from Alamitos Bay (California), analyzed fish with standard lengths up to 142 mm. In both cases, the authors note that the size of halibut at one year of age may be greater than these sizes. Other aging work was conducted with halibut YOY up to 68 mm SL from semiprotected stations of Malaga Cove, California and open coast stations (Sears-Hartley 1994). In laboratory conditions, Gadomski et al (1990) studied the growth of juvenile halibut up to 14.8 mm SL, and concluded that high temperature together with high food density resulted in significant differences in growth.

Our preliminary age determination of California halibut by annual increments from Bahía de Todos Santos, and Estero de Punta Banda, Baja California (México), showed that a minimum length of 180 mm SL could be set as the limit for halibut young-of-the-year.

The present study determined the age, growth, and length for young-of-the-year California halibut, from Bahía de Todos Santos, Estero de Punta Banda, and Bahía de San Quintín, Baja California, México.

Methods

In Bahía de Todos Santos and Estero de Punta Banda, halibut were collected monthly from May 1992 to April 1993. During 1994, the catches were made in February, May, August, and November. In 1995, sampling was conducted during March and August only. In Bahía de San Quintín and the adjacent coast, the study began with an initial survey in May 1993, followed by monthly effort throughout 1994.

The collection sites in the three places are shown in Figure 1. The sampling was directed to young-of-the-year (YOY), juvenile and larger fishes. Two vessels were used in fieldwork, an 8 m boat with stationary motor (350 HP) and a small 4 m fiberglass boat with outboard motor (25 HP) for shallow sites.

To collect halibut, 5-min tows were conducted with a 1.6 m beam trawl (horizontal 1.6 m, vertical 0.343 m opening, 3 mm mesh size); and a 7.5 m otter trawl (10 m length with 19 mm mesh in body and 5 mm in bag end); nets were towed at a speed of approximately 1.5 and 2.0 knots, respectively. Samplings were carried out along 5 and 10 m depth contours, except in the Estero de Punta Banda because 10 m depth was not found. Beam trawls capture primarily small or slow fishes (Kramer and Hunter 1987; Kramer 1990; Allen and Herbinson 1990, 1991), and the otter trawl collect relatively bigger and faster swimming fishes.

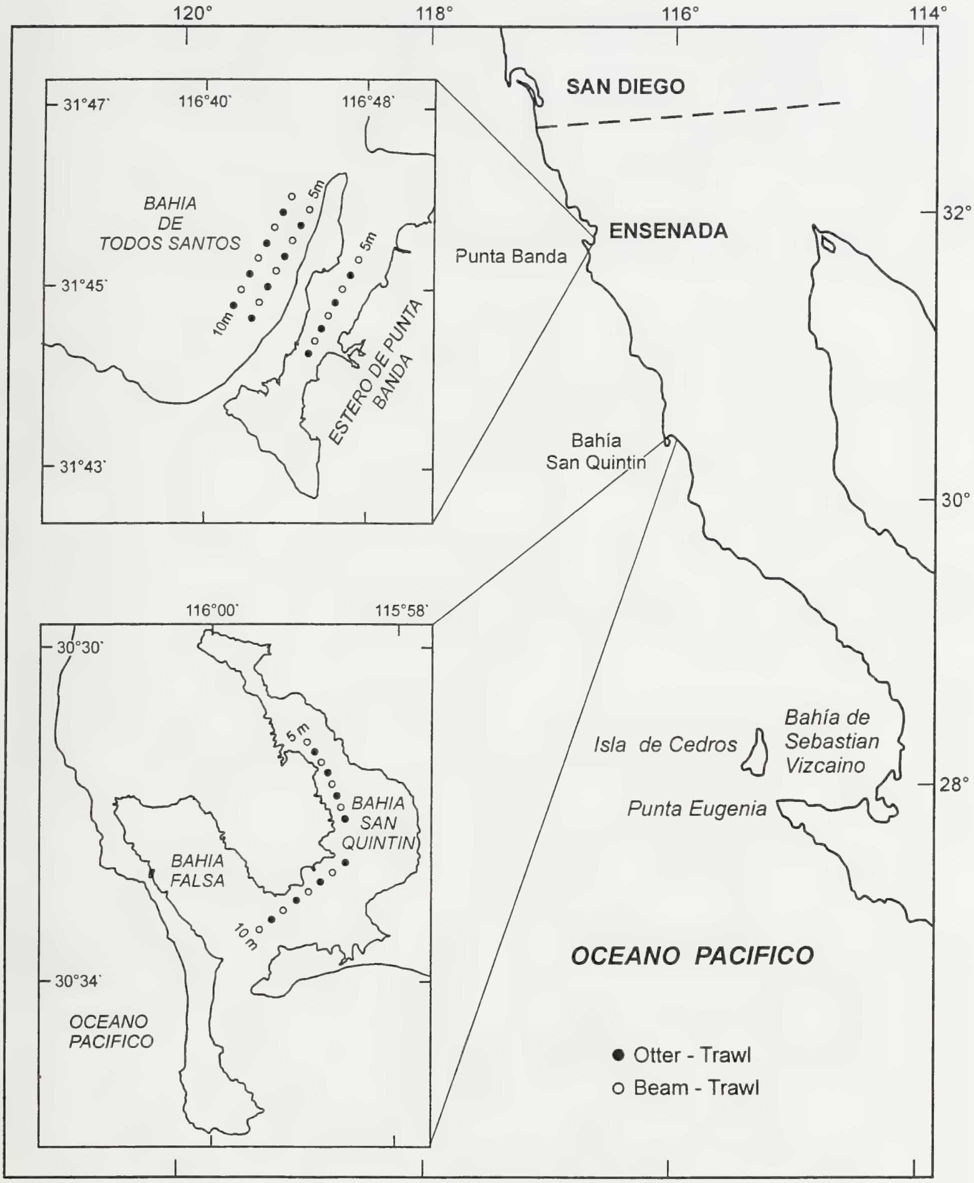
120°
118°
116°
114°
32°
30°
28°
SAN DIEGO
ENSENADA
Punta Banda
Bahía San Quintín
Isla de Cedros
Bahía de Sebastian Vizcaino
Punta Eugenia
OCEANO PACIFICO
● Otter - Trawl
○ Beam - Trawl
31°47'
116°40'
116°48'
31°45'
31°43'
BAHIA DE TODOS SANTOS
ESTERO DE PUNTA BANDA
5m
10m
116°00'
115°58'
30°30'
30°34'
BAHIA SAN QUINTIN
BAHIA FALSA
OCEANO PACIFICO
5 m
10 m

Fig. 1. Location of study sites.

Juvenile halibut were cut off at sizes up to 181 mm SL for YOY, and after the sagittal otoliths were dissected, both were measured and the largest was selected; readings were made trying to work one otolith per each five millimeters. Otoliths were mounted with acrylic resin on glass slides and ground with 30, and 20 mic. lapping film and alumina 0.05 mic. After grinding, otoliths were polished in distilled water on fine velvet. Immersion oil was used to increase the clarity of increments, and examined up to a magnification of 400× with a microscope. Three readings were made in different directions from the central nuclei to the posterior edge, and the average was used in the aging. The mean number of increments calculated from an individual sagitta is equivalent to days of life (Jensen 1990). Because time for first feeding of halibut larvae is between 3.5 to 5 days, four days were added to the mean number of increments counted on the otolith, so that age was equivalent to the days from hatching.

The relationship between age (days) and standard length (mm) was best described with the linear function. Separate equations were obtained for halibut from the three study sites. Lengths were transformed to logarithms and an Analysis of Covariance to determine slope differences was employed.

Results

Our preliminary data, based on annual age readings, showed an average standard length for 1-year-old halibut of 180 mm. With those results, from the total, individuals of California halibut collected in Bahía Todos Santos, Estero de Punta Banda, and Bahía de San Quintín were mostly age group 0 (72.1, 81.9, and 90.6%, respectively). In the same order, percents for age group 1 were 22.4, 11.4, and 4.1%, respectively.

Ninety-nine otoliths were read, 29 from Bahía de Todos Santos, 36 from Estero de Punta Banda, and 34 from Bahía de San Quintín. In the present study the otolith readings were made in halibut with sizes from 21 mm to 181 mm SL.

Separate equations of the linear relationship between age (days) and standard length (mm) were obtained for halibut from the three study sites. Age was equivalent to the days from hatching. The "y" is the standard length (mm) and the "x" is the age in days:

B. Todos Santos: $y = -4.943 + 0.5x$, $r^2 = 0.899$, $n = 29$

E. Punta Banda: $y = -12.85 + 0.496x$, $r^2 = 0.903$, $n = 36$

B. San Quintín: $y = -28.19 + 0.519x$, $r^2 = 0.967$, $n = 34$

The Analysis of Covariance indicated no significant differences between the slopes of the age-length relationship from YOY of Bahía de Todos Santos, Estero de Punta Banda, and Bahía de San Quintín (ANCOVA, $p = 0.419$). Therefore, all the data ($n = 99$) from the three sites were combined to determine one overall growth equation for young-of-the-year (Fig. 2).

$$y = -14.09 + 0.492x,$$

($r^2 = 0.907$, standard error SE of constant = 2.06, SE slope = 0.009), which represents a general mean growth rate of 14.8 mm per month.

The relationship of age at length for all mean data was also fitted with a linear function (Fig. 2):

$$y = 46.35 + 1.843x$$

($n = 99$, $r^2 = 0.907$, S.E. constant = 6.25, S.E. slope = 0.059). With that relationship can be established a limit size for young-of-the-year halibut of 173 mm SL, with a range from 168 to 180 mm SL.

Discussion

In the present study, YOY halibut settled to nearshore waters in Bahía de Todos Santos only in September. YOY settled in Estero de Punta Banda during May,

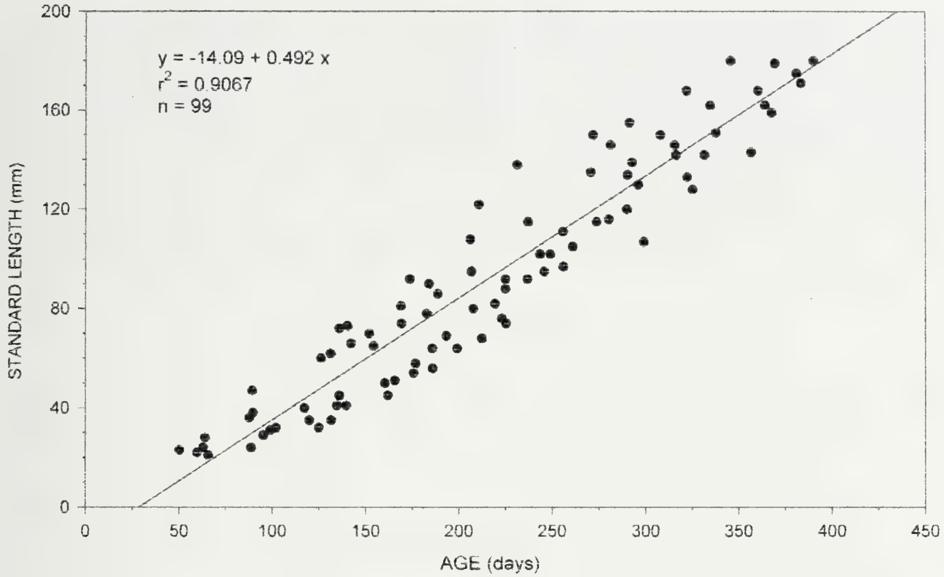

Fig. 2. Age-length relationship for Young-Of-The-Year *Paralichthys californicus* from the northwestern coast of Baja California, México.

September, and November. This coincides with information that halibut are multiple spawners (Moser and Watson 1990), and also, that halibut settle mostly in esteros (Castro-Longoria and Grijalva-Chon 1988; Hammann and Rosales-Casián 1990). In Bahía de San Quintín we observed two periods of halibut settlement, the first from April to July, and second in November–December.

We determined that YOY halibut in our study grow at a rate of 0.49 mm/day. This was different from data presented in others studies off Baja California and California. Hammann and Ramirez-Gonzalez (1990) found a growth rate of 0.26 mm/day in Bahía de Todos Santos, and Carrillo-Cortés (1994) for Todos Santos and the Estero de Punta Banda obtained a growth rate of 0.22 mm/day, both studies were based on annual readings. In Alamitos Bay (California), halibut size ranging from 7 to 77 mm SL, and different and highly variable mean growth rates were determined in three years: 0.35 (1983), 0.71(1984), and 0.98 mm/day (1985); these growth estimates could be influenced by oceanographic conditions, productivity, and the El Niño event of 1982–1983 (Allen 1988). In laboratory conditions, Gadomski et al (1990) found a low growth rate for the post-settlement halibut of 0.7 cm/month. Halibut from Alamitos bay presented a growth range for young-of-the-year halibut from 0.125 to 0.86 mm/day (Jensen 1990), and 0.95 mm/day in the open coast (Sears-Hartley 1994). The highly variable growth rates of halibut shows that studies with distinct range sizes, distinct annual conditions and localities, can change these values, and probably their survival.

Protected areas have been identified as nursery grounds along the Southern California coast (Allen 1988; Allen and Herbinson 1990, 1991; Kramer 1991). However, these habitats are not only relatively rare along the California coast, but the few habitats with a nursery function are severely impacted by human activities, and have been reduced by up to 90% of their original size (Kramer

1990). On the other hand, because the bays and coastal lagoons along Pacific Baja California are relatively pristine, they have a great potential for reproduction, feeding, and refuge for fish species of ecological and economic importance. They are likely major nursery sites and an important source of fishes for Southern California. Little information exists about the coastal ichthyofauna of Baja California, but many species are distributed from Baja California to the Southern California Bight. The ecological role of Bahía de Todos Santos, Estero de Punta Banda, Bahía de San Quintín, and even the open coast should be maintained through careful preservation.

Literature Cited

Allen, L.G. 1988. Recruitment, distribution, and feeding habits of young-of-the-year California halibut (*Paralichthys californicus*) in the vicinity of Alamitos Bay-Long Beach harbor, California, 1983–1985. So. Cal. Acad. Sci. Bull. 87:19–30.

Allen, L.G., R.E. Jensen, and J.R. Sears. 1990. Open coast settlement and distribution of young-of-the-year California halibut (*Paralichthys californicus*) along the Southern California coast between Point Conception and San Mateo Point, June–October, 1988. Pages 145–152 in C.W. Haugen, ed. The California halibut, *Paralichthys californicus*, resource and fisheries. Calif. Dept. Fish and Game, Fish Bull. 174.

Allen, M.J. and K.T. Herbinson. 1990. Settlement of juvenile California halibut, *Paralichthys californicus*, along the the coasts of Los Angeles, Orange, and San Diego counties in 1989. CalCOFI Rep. 31:84–96.

Allen, M.J. and K.T. Herbinson. 1991. Beam-trawl survey of bay and nearshore fishes of the soft-bottom habitat of Southern California in 1989. CalCOFI Rep. 32:112–127.

Carrillo-Cortes, J.A. 1994. Estructura y características poblacionales del lenguado de California *Paralichthys californicus* (AYRES), en la Bahía de Todos Santos y el Estero de Punta Banda, durante los meses de abril de 1992 a marzo de 1993. Bachelor thesis, Universidad Autónoma de Baja California, Facultad de Ciencias Marinas. 52 p.

Castro-Longoria, R. and J.M. Grijalva-Chon. 1988. Ichthyoplankton from Estero de Punta Banda, BC, México during spring-summer period, 1985. Ciencias Marinas 14(1):57–79.

Gadomski, D.M., S.M. Caddell, L.R. Abbott, and T.C. Caro. 1990. Growth and development of larval and juvenile California halibut, *Paralichthys californicus*, reared in laboratory. Pages 85–98, in C.W. Haugen, ed. The California halibut, *Paralichthys californicus*, resource and fisheries. Calif. Dept. Fish and Game, Fish Bull. 174.

Hammann, M.G. and A.A. Ramirez-Gonzalez. 1990. California halibut *Paralichthys californicus*, in Todos Santos Bay, Baja California, México. Pages 127–144, in C.W. Haugen, ed. The California halibut, *Paralichthys californicus*, resource and fisheries. Calif. Dept. Fish and Game, Fish Bull. 174.

Hammann, M.G and J.A. Rosales-Casián. 1990. Taxonomía y estructura de la comunidad de peces del Estero de Punta Banda y Bahía de Todos Santos, Baja California, México. Cap. 6: 153–192 *In*: Rosa-Velez J. de la y F. Gonzales-Farías (eds) Temas de Oceanografía Biológica en México. Universidad Autónoma de Baja California, Ensenada. 337 p.

Jensen, R.E. 1990. The aging, validation, and back-calculation of the date of birth and settlement of young-of-the-year California halibut (*Paralichthys californicus*) into Alamitos Bay, California using a new technique for the grinding of sagittal otoliths. M.S. Thesis. California State University, Northridge, 80 pp.

Kramer, S.H. 1990. Distribution and abundance of juvenile California halibut, *Paralichthys*, in shallow waters of San Diego County. Calif. Dept. Fish Game, Fish Bull. 174.

Kramer, S.H. 1991. The shallow-water flatfishes of San Diego county. CalCOFI Rep. 32:128–142.

Kramer, S.H. and J.R. Hunter. 1987. Southern California wetland/ shallow water habitat investigation, annual report for the fiscal year 1987. U. S. Dep. Commerce, NOAA, NMFS, SWFSC, La Jolla, Calif. 12 pp.

Moser, H.G. and W. Watson. 1990. Distribution and abundance of early life history stages of the California waters, *Paralichthys californicus*, and comparison with the fantail sole, *Xystreurys* *liolepis,* Pages 31–84, in C.W. Haugen, ed. The California halibut, *Paralichthys californicus,* resource and fisheries. Calif. Dept. Fish and Game, Fish Bull. 174.

Rosales-Casián, J.A. 1997a. Inshore soft-bottom fishes of two coastal lagoons on the northern Pacific coast of Baja California. CalCOFI Rep. 38, 180–192.

Rosales-Casián, J.A. 1997b. Estructura de la comunidad de peces y el uso de los ambientes de bahías, lagunas y costa abierta en el Pacífico norte de Baja California. PhD thesis, CICESE, Ecología Marina, CICESE. 201 p.

Sears-Hartley, J.R. 1994. Age, growth and early life history of *Paralichthys californicus* derived from otolith microstructure. M.S. Thesis. California State University, Northridge. 54 pp.

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Research Notes

Reproduction in the San Lucan Alligator Lizard, *Elgaria paucicarinata* (Anguidae) from Baja California Sur, Mexico

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Elgaria paucicarinata is restricted to the Cape Region of Baja California Sur (Grismer 2002). While Lais (1976) summarized the biology of this species and Grismer (2002) collected hatchlings during August, information on the reproductive biology is unknown. The purpose of this report is to present information on the reproductive cycles from a histological examination of gonadal material and provide the first clutch sizes for this species.

Eighteen male (mean snout-vent length, SVL = 94 mm ± 11 SD, range = 75–116 mm) and nine female *E. paucicarinata* (mean SVL = 91 mm ± 9 SD, range = 75–105 mm) from the Museum of Vertebrate Zoology, Berkeley (MVZ), Natural History Museum of Los Angeles County, Los Angeles (LACM), La Sierra University, Riverside (LSUHC) and the San Diego Society of Natural History, San Diego (SDSNH) were examined (see Appendix).

The left testis and left ovary were removed from males and females respectively. Gonads were embedded in paraffin, sectioned at 5 μm, and stained with Harris' hematoxylin followed by eosin counterstain. Oviductal eggs or enlarged follicles ($>$ 4 mm length) were counted but were not examined histologically. An unpaired *t*-test was performed to compare male and female mean body sizes.

Differences between male and female mean body sizes (SVL) were not significant ($t = 0.84$, $df = 25$, $P = 0.41$). Testicular histology of *E. paucicarinata* was similar to that of *E. multicarinata* and *E. kingii* (Goldberg 1972, 1975). Stages of the testicular cycle are presented in Table 1. Testes of *E. paucicarinata* in recrudescence (May–August) contained spermatogonia and primary spermatocytes. Spermatids were occasionally observed but no sperm were present. Testes undergoing spermiogenesis (August, October and November) contained rows of metamorphosing spermatids lining the lumina of the seminiferous tubules (Table 1). The single regressed testis from April contained primarily spermatogonia. A few rows of metamorphosing spermatids remained in some seminiferous tubules but the germinal epithelium was exhausted.

The seasonal ovarian cycle is presented in Table 2. Oviductal females were collected in March (LACM 15131, SVL = 87 mm, 6 eggs) and April (MVZ 45368, SVL = 98 mm, 8 eggs). A female collected in October (LACM 25059, SVL = 8 mm) had 6 enlarged follicles > 4 mm, with yolk deposition underway in a seventh follicle which measured 3 mm in length. A clutch of seven eggs would likely have been produced the following spring. Mean clutch size (n = 3)

Table 1. Seasonal testicular cycle of *Elgaria paucicarinata.*

Month	*n*	Regression	Recrudescence	Spermiogenesis
April	1	1	0	0
May	3	0	3	0
June	2	0	2	0
July	2	0	2	0
August	4	0	2	2
October	5	0	0	5
November	1	0	0	1

Table 2. Seasonal ovarian cycle of *Elgaria paucicarinata.*

Month	*n*	No yolk deposition	Enlarged follicles (> 4 mm length)	Oviductal eggs
March	1	0	0	1
April	1	0	0	1
July	3	3	0	0
August	2	2	0	0
October	2	1	1	0

is 7.0 ± 1.0 SD (range = 6–8). These are the first clutch sizes recorded for *E. paucicarinata.* Females with inactive ovaries (i.e., no yolk deposition) were collected in July, August and October (Table 2).

The reproductive cycle of *E. paucicarinata* is similar to that of *E. kingii* (Goldberg 1975) which has an autumn period of spermiogenesis. Fall spermiogenesis appears to be unusual for North American lizards (Goldberg 1975). By producing sperm and presumably mating in autumn, both *E. paucicarinata* and *E. kingii* initiate yolk deposition during October followed by ovulation in spring. The timing of the reproductive cycles of *E. paucicarinata* and *E. kingii* differ markedly from those of *E. coerulea* (Vitt 1973), *E. multicarinata* (Goldberg 1972) and *E. panamintina* (Goldberg and Beaman 2003), all of which undergo spermiogenesis in the spring. The timing of the breeding cycle in *E. paucicarinata* and *E. kingii* probably coincides with monsoonal moisture patterns that pass through their ranges from July to early October.

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Literature Cited

Goldberg, S. R. 1972. Reproduction in the southern alligator lizard *Gerrhonotus multicarinatus.* Herpetologica 28:267–273.

———. 1975. Reproduction in the Arizona alligator lizard, *Gerrhonotus kingi.* Southwest. Nat. 20: 412–413.

———, and K. R. Beaman. 2003. *Elgaria panamintina* (Panamint Alligator Lizard). Reproduction. Herpetol. Rev. 34:143.

Grismer, L. L. 2002. Amphibians and reptiles of Baja California including its Pacific islands and the islands in the Sea of Cortés. Univ. Calif. Press, Berkeley, xiii + 399 pp.

Lais, P. M. 1976. *Gerrhonotus paucicarinatus* Fitch San Lucan alligator lizard. Cat. Am. Amph. Rept. 188.1-2.

Vitt, L. J. 1973. Reproductive biology of the anguid lizard, *Gerrhonotus coeruleus principis*. Herpetologica 29:176–184.

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Appendix

Specimens of *Elgaria paucicarinata* examined from the Museum of Vertebrate Zoology (MVZ), Natural History Museum of Los Angeles County (LACM), La Sierra University Herpetology Collection (LSUHC) and San Diego Society of Natural History (SDSNH).

MVZ 45367, 45368, 50078, 50079; LACM 15131, 25027, 25028, 25059, 74274, 92711, 92712, 92714–92716, 92718–92720, 99441, 109374, 109377, 126985; SDSNH 45008, 45009, 45097, 45100, 45101; LSUHC 2445.

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Research Notes

Reproduction in the San Lucan Banded Rock Lizard, *Petrosaurus thalassinus* (Phrynosomatidae) from Baja California Sur, Mexico

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Petrosaurus thalassinus is restricted to the Cape Region of Baja California, occurring in four disjunct populations (Grismer 2002). The biology of this species was summarized by Grismer (2002), however information on the reproductive biology in *P. thalassinus* is limited to anecdotal accounts (Asplund 1967; Grismer 2002). The purpose of this paper is to present information on the reproductive cycle from a histological examination of gonadal material and to provide the first clutch sizes for this species.

Forty-four male (mean snout-vent length, SVL = 110 mm ± 19 SD, range = 80–152 mm), sixteen female (mean SVL = 90 mm ± 14 SD, range = 71–110 mm), and two neonate *P. thalassinus* (mean SVL = 35 mm ± 1.4 SD, range = 34–36 mm) from the Natural History Museum of Los Angeles County (LACM), San Diego Society of Natural History (SDSNH) and University of Arizona (UAZ) were examined (Appendix).

The left testis and left ovary were removed from males and females respectively. Gonads were embedded in paraffin, sectioned at 5 μm and stained with Harris' hematoxylin followed by eosin counterstain. Oviductal eggs or enlarged follicles (> 6 mm length) were counted but not examined histologically. An unpaired *t*-test was performed to compare male and female mean body sizes. The relationship between female body size and clutch size was investigated by linear regression analysis.

Mean male body size (SVL) was significantly larger than that of females ($t = 4.0$, $df = 58$, $P < 0.001$). Stages of the testicular cycle are presented in Table 1. Regressed testes of *P. thalassinus* (May–September) contained spermatogonia and Sertoli cells. The single testis in recrudescence (May) exhibited a proliferation of primary spermatocytes for the next period of spermiogenesis. Testes undergoing spermiogenesis (February–May) contained rows of metamorphosing spermatids and spermatozoa. During May, 55% of the sample was in late spermiogenesis. Germinal epithelium consisted of a few layers of cells and small clusters of sperm lined the lumina of the seminiferous tubules. The smallest reproductively active male (i.e., late spermiogenesis) was LACM 128018 which measured 80 mm SVL.

The seasonal ovarian cycle is presented in Table 2. Females with enlarged follicles (> 6 mm length) and oviductal eggs were present in April–May (Table 3). Mean clutch size (n = 10) is 8.6 ± 3.9 SD (range = 4–18). Linear regression analysis revealed there was no significant correlation ($r = 0.61$, $P = 0.061$) between female body size (SVL) and clutch size for 10 *P. thalassinus*. These are

Table 1. Seasonal testicular cycle of *Petrosaurus thalassinus*.

Month	*n*	Regression	Recrudescence	Spermiogenesis	Late spermiogenesis
February	1	0	0	1	0
March	1	0	0	1	0
April	2	0	0	2	0
May	33	4	1	10	18
June	3	3	0	0	0
July	1	1	0	0	0
August	2	2	0	0	0
September	1	1	0	0	0

the first clutch sizes recorded for *P. thalassinus*. Females with inactive ovaries (i.e., no yolk deposition) were observed in May and August. Three females from May (Table 2) were undergoing moderate yolk deposition (LACM 127996, SVL 73 mm, 3 ovarian follicles, 5.1 mm length ± 0.55 SD; LACM 128001, SVL 83 mm, 5 ovarian follicles, 4.7 mm length ± 0.63 SD; LACM 127997, SVL 83 mm, 8 ovarian follicles, 5.6 mm length ± 0.67 SD). It is uncertain if all follicles would have completed yolk deposition and were not considered as clutches. The smallest reproductively active female (i.e., moderate yolk deposition) was LACM 127996 which measured 73 mm SVL. Two neonates (UAZ 22348, 22349) collected 25 July measured 35.0 mm SVL ± 1.4 SD, range = 34–36 mm. Asplund (1967) observed hatchlings of *P. thalassinus* during August and speculated that breeding occurred before late summer. Data presented herein confirms that *P. thalassinus* breeds early in the year. Grismer (2002) observed gravid *P. thalassinus* from mid-April to mid-August and hatchlings from mid-July to mid-August at San Bartolo. *Petrosaurus thalassinus* is active year-round (Grismer 2002) allowing reproduction to begin early in the year.

The timing of female reproduction in *P. thalassinus* is similar to that of other species of *Petrosaurus* from Baja California. Gravid females of *P. mearnsi* were observed in May and hatchlings from August to October, *P. repens* was reported to breed in spring, with egg deposition occurring in summer and hatchlings appearing in late summer to early fall, and gravid females of *P. slevini* were observed in June with mating occurring in spring and hatchlings appearing in late summer and early fall (Grismer 2002). In southern California, two *P. mearnsi* females from Riverside County with oviductal eggs were found in June (Hain 1965) and one from San Diego County in July (Cozens 1974), suggesting the

Table 2. Seasonal ovarian cycle of *Petrosaurus thalassinus*.

Month	*n*	No yolk deposition	Early yolk deposition	Moderate yolk deposition (follicles< 6 mm)	Enlarged follicles (> 6 mm)	Oviductal eggs
April	3	0	0	0	2	1
May	12	1	1	3	3	4
August	1	1	0	0	0	0

Table 3. Clutch sizes for 10 *Petrosaurus thalassinus* estimated from counts of yolked follicles > 6 mm length or oviductal eggs.

Date	SVL	Clutch size	Source
10–12 April 1978	110	7	LACM 127408
10–12 April 1978	102	9	LACM 127407
30 April 1978	94	8[1]	LACM 127958
1 May 1978	88	7[1]	LACM 127962
1 May 1978	91	4[1]	LACM 127961
2 May 1978	93	8[1]	LACM 127975
10 May 1978	110	18	LACM 128012
10 May 1978	78	6	LACM 128017
11 May 1978	108	12	LACM 128028
23–28 May 1975	74	7[1]	LACM 116389

[1] Oviductal eggs, all other females contained enlarged follicles.

ovarian cycle may be delayed in the north compared to Baja California populations.

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Literature Cited

Asplund, K. K. 1967. Ecology of lizards in the relictual cape flora, Baja California. Am. Midl. Nat. 77:462-475.

Cozens, T. R. 1974. The behavioral ecology of the banded rock lizard: *Petrosaurus mearnsi* (Sauria: Iguanidae). Unpublished M.S. Thesis, San Diego State University, San Diego, California. 87 pp.

Grismer, L. L. 2002. Amphibians and Reptiles of Baja California including its Pacific Islands and the islands in the Sea of Cortés. University of California Press, Berkeley, xiii + 399 pp.

Hain, M. L. 1965. Ecology of the lizard *Uta mearnsi* in a desert canyon. Copeia 1965:78-81.

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Appendix

Specimens of *Petrosaurus thalassinus* examined from the Natural History Museum of Los Angeles County (LACM), San Diego Society of Natural History (SDSNH) and the University of Arizona (UAZ).

LACM 51835, 64378, 64379, 64381, 95411, 99425, 116389, 127406–127408, 127958, 127961–127972, 127975, 127977, 127980–127983, 127989, 127994, 127996–127999, 128001, 128002, 128005, 128009, 128010, 128012, 128014, 128016–128018, 128021, 128025, 128027, 128028, 128030, 128031, 128033, 128034, 138242; SDSNH 30041, 38072, 45041, 45050, 52986; UAZ 22348, 22349, 22391.

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Holmes, T. Jr., and S. Speak. 1971. Reproductive biology of *Myotis lucifugus.* J. Mamm., 54:452–458.

Brattstrom, B. H. 1969. The Condor in California. Pp. 369–382 *in* Vertebrates of California. (S. E. Payne, ed.), Univ. California Press, xii + 635 pp.

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PROCEDURE

All manuscripts should be submitted to the Editor, Daniel A. Guthrie, W. M. Keck Science Center, 925 North Mills Avenue, Claremont, CA 91711. **Authors are requested to submit the names, addresses and specialities of three persons who are capable of reviewing the manuscript. Evaluation of a paper** submitted to the BULLETIN begins with a critical reading by the Editor; several referees also check the paper for scientific content, originality, and clarity of presentation. Judgments as to the acceptability of the paper and suggestions for enhancing it are sent to the author at which time he or she may be requested to rework portions of the paper considering these recommendations. The paper then is resubmitted on disk in word format and may be re-evaluated before final acceptance.

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Cover: Ospreys nesting on cardon cactus (*Pachycereus pringlei*) at Estero de Kino, Sonora, Mexico. Photo by D. W. Anderson